

LONDON
SCHOOL of
HYGIENE
& TROPICAL
MEDICINE



LSHTM Research Online

Liddell, FDK; (1978) Mortality of Quebec chrysotile workers in relation to radiological findings while still employed. PhD thesis, London School of Hygiene & Tropical Medicine. DOI: <https://doi.org/10.17037/PUBS.04656049>

Downloaded from: <https://researchonline.lshtm.ac.uk/id/eprint/4656049/>

DOI: <https://doi.org/10.17037/PUBS.04656049>

Usage Guidelines:

Please refer to usage guidelines at <https://researchonline.lshtm.ac.uk/policies.html> or alternatively contact researchonline@lshtm.ac.uk.

Available under license. To note, 3rd party material is not necessarily covered under this license: <http://creativecommons.org/licenses/by-nc-nd/3.0/>

<https://researchonline.lshtm.ac.uk>

MORTALITY OF QUEBEC CHRYSOTILE WORKERS
IN RELATION TO
RADIOLOGICAL FINDINGS WHILE STILL EMPLOYED

Francis Douglas Kelly Liddell

Thesis submitted for the degree of
PhD

*TUC Centenary Institute of Occupational Health
London School of Hygiene and Tropical Medicine*

July 1978

LIBR.
LONDIN.
UNIV.

A B S T R A C T

Two cohorts of Quebec chrysotile miners and millers were selected in order to study how radiological changes in asbestos workers predict mortality. Cohort "A" comprised 988 men, with dust exposure, smoking history, respiratory symptoms and lung function recorded in 1967-68, and six independent readings of an earlier chest radiograph; 130 men had died before 1976. Cohort "B" comprised all 4,559 men not in Cohort "A" who were born 1891 through 1920, with at least a month's employment and an x-ray; dust exposure, smoking history and a single x-ray reading were obtained. By the end of 1975, there had been 1,453 deaths in Cohort "B".

A high Relative Risk (RR) of *total mortality* was related to each radiographic feature, cigarette smoking, excessive dust exposure, and, in Cohort "A", dyspnoea and poorer function.

Death from *pneumoconiosis* was associated with small irregular parenchymal opacities, of profusion usually greater than 1/0, and with heavy dust exposure, but not with smoking.

Almost all who died from *chest cancer* had smoked cigarettes (very high RR), had been heavily exposed to asbestos (high RR), or both. About half their x-rays showed pneumoconiotic change. There was insufficient evidence to determine whether chest cancer was a complication of asbestosis or an independent reaction to asbestos exposure. Five of the six *mesothelioma* cases had positive but varied radiographic appearances.

The contribution of asbestos dust to some deaths attributed to *heart disease* was substantiated by high RRs for severe exposure, and for small parenchymal opacities; smokers, and the breathless, also had high risks.

Other neoplasms showed no consistent dust or x-ray patterns. RRs of deaths from some other causes were high for certain radiographic features. Not all these results can yet be explained.

The main findings validated the UICC/Cincinnati classification convincingly. Studies to permit generalization are recommended.

C O N T E N T S

	Page
<u>Abstract</u>	2
 <u>Chapter 1</u>	
INTRODUCTION	17
 <u>Chapter 2</u>	
ASBESTOS: FORMS, USES AND HEALTH EFFECTS	
2.1 Introduction	22
2.2 Forms and supplies of asbestos	23
2.3 Uses of asbestos	27
2.4 Geology and exploitation	32
2.5 Dust exposure and inhalation	33
2.6 Pulmonary fibrosis; asbestosis	39
2.7 Diagnosis of asbestosis	42
2.8 Is asbestosis progressive?	44
2.9 Asbestosis and mortality	45
2.10 Lung cancer	46
2.11 Mesothelioma	49
2.12 Cancer of the gastro-intestinal tract	54
2.13 Cancer of the larynx	55
2.14 Other health hazards	56
2.15 Summary; gaps in knowledge; thesis objectives	58

Chapter 3

RADIOLOGICAL CLASSIFICATION

3.1	Introduction	63
3.2	International classifications up to 1958	63
3.3	Classifications of asbestosis	66
3.4	The UICC/Cincinnati (or U/C) classification	67
3.5	The ILO U/C (1971) classification	70
3.6	Standard radiographs	73
3.7	Radiographic technique	75
3.8	Summary	76

Chapter 4QUEBEC CHRYSOTILE STUDIES I:
POPULATIONS AND MEASURES OF EXPOSURE

4.1	Introduction	78
4.2	Principles	81
4.3	Work histories	83
4.4	Dust measurements	85
4.5	Exposure calculations	88
4.6	The "main mortality cohort"	92
4.7	The "physiology cross-section"	95
4.8	Procedures for reading 15,689 radiographs	97
4.9	The "radiographic progression cohort"	99
4.10	Summary	101

Chapter 5

QUEBEC CHRYSOTILE STUDIES II: FINDINGS

5.1	Introduction	103
5.2	Radiological changes in relation to dust exposure	103
5.3	Respiratory symptoms and lung function in relation to dust exposure	111
5.4	Interrelationships of signs and symptoms	116
5.5	Mortality in relation to asbestos exposure	118
5.6	Mortality in relation to radiographic changes	130
5.7	Summary	131

Chapter 6

QUEBEC CHRYSOTILE FINDINGS AND OTHERS COMPARED

6.1	Introduction	135
6.2	Other investigations in Quebec	135
6.3	Other studies of workers in chrysotile	142
6.4	Asbestos dose related to the response of lung cancer	143
6.5	The interaction of asbestos dust and cigarette smoking	149
6.6	Mesothelioma	151
6.7	Summary	155

Chapter 7

THESIS OBJECTIVES AND MATERIALS

7.1	Introduction	158
7.2	Objectives	161
7.3	Factors for study	162
7.4	Criteria for selecting a study population	165
7.5	Cohort "A": definition, sources and numbers	168
7.6	Cohort "B": definition, sources and numbers	177
7.7	Summary	184

Chapter 8

METHODS

8.1	Introduction	186
8.2	Modes of reasoning	187
8.3	Comparative composite cohort analysis	189
8.4	<i>A posteriori</i> methods of cohort analysis	193
8.5	Methods for <i>a priori</i> analysis of Cohorts "A" and "B"	196
8.6	Methods for <i>a posteriori</i> analysis of Cohorts "A" and "B"	205
8.7	Summary	207

Chapter 9

DESCRIPTION OF THE STUDY COHORTS

9.1	Introduction	209
9.2	The men of Cohort "A"	209
9.3	Era 3 of Cohort "B"	224
9.4	The three Eras of Cohort "B"	225
9.5	The men of Cohort "B"	228
9.6	Randomization of men in Cohort "B" to film readers	239
9.7	Summary	242

Chapter 10

FINDINGS I

10.1	Introduction to Chapters 10 through 13	244
10.2	Total mortality in men with "less-than-normal" radiographs	248
10.3	Cause-specific mortality in the "less-than-normals"	255
10.4	Total mortality and specific radiographic changes	255
10.5	Total mortality and non-radiographic factors	259

Chapter 11

FINDINGS II

11.1	Introduction	264
11.2	Pneumoconiosis	264
11.3	Cancer of the chest	273
11.4	Mesothelioma	283
11.5	Respiratory tuberculosis	286
11.6	Other respiratory conditions	288
11.7	Heart disease	288

Chapter 12

FINDINGS III

12.1	Introduction	292
12.2	Cancer of the gastro-intestinal tract	292
12.3	Cancer of the larynx	294
12.4	Other causes	298

Chapter 13

SUMMARY OF FINDINGS

13.1	Introduction; total mortality	304
13.2	Asbestos-related diseases of the respiratory system	305
13.3	Other respiratory diseases; heart disease	306
13.4	Other cancers	307
13.5	Strokes; accidents; other causes	307
13.6	Conclusion	308

Chapter 14

DISCUSSION, SYNTHESIS AND RECOMMENDATIONS

14.1	Introduction	309
14.2	Mortality in relation to dust exposure, smoking and mining area	310
14.3	Limitations of <i>a priori</i> argument	313
14.4	Total mortality in relation to signs and symptoms	314
14.5	Pneumoconiosis and related conditions	317
14.6	Neoplasia	322
14.7	Other causes of death	324
14.8	Validation of the radiographic classification	325
14.9	Surveillance of the asbestos worker	330
14.10	Other possible developments	331

Postscript

ORIGINALITY; IMPORTANCE;
RESPONSIBILITIES; ACKNOWLEDGEMENTS

335

Bibliography

339

Appendix

INSTRUCTIONS FOR USING UICC/CINCINNATI CLASSIFICATION
29th December, 1967

367

ANNEXPage in VOLUME 2Contents of Annex

2

Cohort "A"

Lay-outs

3-4

Leading data

5-151

Cohort "B"

Lay-outs

152-153

Leading data

154-348

L I S T O F T A B L E S

	Page
<u>Chapter 2</u>	
2.1 Proportional mortality from lung cancer and mesothelioma	50
2.2 Latent periods in 245 deaths from cancer of the chest	60
<u>Chapter 5</u>	
5.1 Prevalence of breathlessness by dust exposure	113
5.2 Mortality to end-1969 of Quebec miners and millers	120
5.3 Relative risks for respiratory cancer and asbestos exposure at four stage of enquiry	125
<u>Chapter 6</u>	
6.1 Findings in three radiological surveys of Quebec chrysotile miners and millers	138
6.2 Mortality among 544 Quebec asbestos mine and mill employees, 1961-73	140
6.3 Mortality among Quebec asbestos miners and millers	141
<u>Chapter 7</u>	
7.1 Classification of causes of death	164
7.2 Calculation of dust exposures	173
7.3 Basic information for men in Cohort "A"	175
7.4 Basic information for men in Cohort "B"	181
7.5 Quality of record linkage	183

Chapter 8

8.1	Translations of x-ray readings	202
-----	--------------------------------	-----

Chapter 9

9.1	Mining area, service, exposure and smoking: Cohort "A"	211
9.2	Service and exposure: Cohort "A"	212
9.3	Prevalence of radiographic changes: Cohort "A"	213
9.4	Radiographic scores: Cohort "A"	215
9.5	Respiratory symptoms: Cohort "A"	216
9.6	Height, weight and lung function: Cohort "A"	218
9.7	Lung function and adiposity related to age and height	219
9.8	Matrix of correlations: Cohort "A"	222
9.9	Deaths in Cohort "A"	223
9.10	Deaths in Cohort "B", Era 3	226
9.11	Differences between Eras in Cohort "B"	227
9.12	Mining area, service, exposure and smoking: Cohort "B"	230
9.13	Service and exposure: Cohort "B" (Asbestos) (Thetford Mines)	231 232
9.14	Prevalence of radiographic changes: Cohort "B"	234
9.15	Radiographic scores: Cohort "B"	235
9.16	Matrix of correlations: Cohort "B"	236
9.17	Deaths in Cohort "B"	237
9.18	Radiographic abnormality, by reader	241

Chapter 10

10.1	Radiographic abnormality and total mortality	249
10.2	Distributions of man-years by age	251
10.3	"Sensitivity" and "specificity", by reader	252
10.4	"Barndoor" normal films and total mortality	254
10.5	Radiological abnormality and cause-specific mortality	256
10.6	Specific radiographic changes and total mortality	257
10.7	Total mortality by mining area, dust exposure and smoking habit	260
10.8	Respiratory symptoms and total mortality	262
10.9	Lung function, adiposity and total mortality	263

Chapter 11

11.1	Deaths from pneumoconiosis related to radiographic changes and other factors	266
11.2	Radiographic changes in pneumoconiosis deaths	268
11.3	Parenchymal changes in pneumoconiosis deaths	269
11.4	Radiographic changes in pneumoconiosis deaths, and controls	271
11.5	Asbestos dust exposure and smoking habit in pneumoconiosis deaths and in controls	272
11.6	Pneumoconiosis deaths with and without radiographic changes	274
11.7	Deaths from cancer of the chest related to radiographic changes and other factors	275
11.8	Radiographic changes in chest cancer deaths	277
11.9	Parenchymal changes in chest cancer deaths	278
11.10	Radiographic changes in chest cancer deaths, and controls	280

Chapter 11 (continued)

11.11 Asbestos dust exposure and smoking habit in chest cancer deaths and in controls	281
11.12 Chest cancer cases with and without radiographic changes	282
11.13 Mesothelioma: one case in Cohort "A"	284
11.14 Mesothelioma: five cases in Cohort "B"	285
11.15 Deaths from respiratory tuberculosis related to radiographic changes and other factors	287
11.16 Deaths from other respiratory diseases related to radiographic changes and other factors	289
11.17 Deaths from heart disease related to radiographic changes and other factors	290

Chapter 12

12.1 Deaths from cancer of oesophagus or stomach related to radiographic changes and other factors	293
12.2 Deaths from cancer of colon or rectum related to radiographic changes and other factors	295
12.3 Deaths from other cancers of the abdomen related to radiographic changes and other factors	296
12.4 Deaths from laryngeal cancer related to radiographic changes and other factors	297
12.5 Deaths from other cancers related to radiographic changes and other factors	299
12.6 Deaths from cerebro-vascular diseases related to radiographic changes and other factors	300
12.7 Deaths from accidents related to radiographic changes and other factors	301
12.8 Deaths from other known causes related to radiographic changes and other factors	303

Chapter 14

14.1 Dates of birth: Cohort "B" and "main mortality
cohort"

312

LIST OF FIGURES

	Page
<u>Chapter 2</u>	
2.1 X-ray spectra	28
2.2 Scheme of mining and milling processes	34
2.3 Electron micrographs of asbestos fibres	40
<u>Chapter 4</u>	
4.1 Map of the asbestos-mining region of South-Eastern Quebec	79
<u>Chapter 5</u>	
5.1 Radiological scores	106
5.2 Lung function, smoking and dust exposure	114
<u>Chapter 6</u>	
6.1 Lung cancer mortality by dust and smoking	152
6.2 Latent periods in mesothelioma	154

Chapter 1

I N T R O D U C T I O N

The uses of asbestos, the "magic mineral" are stated to be innumerable, and certainly more than three thousand have been identified by Rosato (1959). The President of the Quebec Asbestos Mining Association called asbestos "a unique product, a natural material of great value providing characteristics which are found in no other product and which are of inestimable service" (Messel, 1978). Although these views are not disinterested, they are largely endorsed by unbiased experts. Thus, Gilson (1965) commented on the surprisingly diverse and expanding uses of asbestos, and that it had much to its credit, for example such products as incombustible buildings, fire-resistant bulkheads, fire-proof clothing, brake shoes and clutch plates, all affecting safety and health. Further, it allowed great savings in energy through its use for insulation.

World production of asbestos has grown steadily from a few tons a year just a century ago (50 tons were produced in Quebec in 1878) to nearly six million short tons in 1977 (Quebec Asbestos Mining Association, 1978), at a value of almost 2,000 million dollars. Although the bulk comes from Russia (44.8 per cent in 1977, all chrysotile), Canada (27.4 per cent, chrysotile) and South Africa (13.0 per cent, chrysotile, crocidolite and amosite), all countries make use of it.

Undoubtedly, asbestos is a most important mineral; but equally certainly it can have adverse effects on health. It has been known since the turn of the century to lead to pulmonary fibrosis, which in those days of extremely severe exposure was often rapidly fatal. Before this and other health hazards were officially recognized (in the 1930s in Britain), environmental hygiene for both production and manufacture was poor in the extreme. After implementation of the Asbestos Regulations 1931, concentrations of airborne dust were much reduced, but remained very high, by modern standards, both here and in the mines and mills which produce asbestos. However, even in such conditions, the deleterious effects on the health of those exposed to asbestos dust are not usually manifest for many years. Thus, studies over the last quarter of a century, which have shown excess mortality and morbidity in asbestos workers, and which have aroused great concern about hygiene standards, have been examining responses to past doses which, in most parts of the world, would be unthinkable high today.

Nevertheless, it remains essential to make the most thorough possible epidemiological investigations of health in relation to asbestos exposure. These are, indeed, aided by knowledge of severe historical exposures, although interpolation of fitted dose-response relationships within the region of present day exposures is of great difficulty. Further, although concerns about the health of asbestos workers have led to attempts to develop substitutes, there is little likelihood of complete replacement of asbestos for many years. Nor are substitutes necessarily the answer; it may be that the properties needed to mimic those of asbestos are themselves fibrogenic or carcinogenic.

nogenic.

There are known to be interrelationships between all the responses to exposure, and many of the responses exhibit dose-response relationships, although these differ markedly from one fibre type to another. However, little is known as to the sequence in which the various signs and symptoms manifest themselves; nor has there been any reliable evidence on how any particular sign, symptom or combination can predict mortality. Radiological changes can, since 1967, be categorized into a classification of the pneumoconioses which was devised with particular reference to asbestos, the appearances of which could not be adequately recorded in earlier classifications. The irregular small opacities in the lung parenchyma and the pleural changes that are often observed in the x-ray films of asbestos workers, but comparatively seldom in others, can therefore be taken as reasonably specific to asbestos exposure, and thus might be expected to be better than other signs in indicating state of asbestos-related disease and so of predicting mortality in populations of asbestos workers.

The broad objective of this research was to determine the extent to which radiographic changes could predict mortality in persons who had been exposed to asbestos. Should prediction turn out to be good, it would serve as the best possible validation of the radiological classification. Further, light might be cast on the value of radiology in the surveillance of a working population. When the research reported here was already well advanced, a meeting of x-ray readers from six countries, at an important symposium on asbestos in Johannesburg (Glen, 1978), agreed that research on morbidity and mortality

associated with x-ray abnormality was "crucial", because "the importance of radiology depends on its ability to predict illness and death, rather than on its sensitivity to asbestos exposure" (Irwig, 1978).

This thesis is organized in a further thirteen chapters, of which the first considers the history, forms, uses and consumption of asbestos, and its health effects. Chapter 3 discusses radiological classification, tracing development from 1930 to the latest international classification, i.e. the ILO U/C (1971) international classification of radiographs of the pneumoconioses. Full details are given of the U/C classification agreed to in 1967; this, the basis of the ILO U/C (1971) classification, was used for the film reading essential to this research. The next two chapters are concerned with the health of Quebec chrysotile miners and millers, by far the largest group exposed to a single fibre to have been investigated: Chapter 4 describes the populations and measures of exposure defined and studied by Professor J. Corbett McDonald and his colleagues (including the author) at McGill University; the findings from these studies are reviewed in Chapter 5. The following chapter examines findings from many diverse investigations in the context of those from McGill; particular attention is paid to (a) the relationships between dose (exposure to asbestos dust) and response (lung cancer mortality) and (b) the interaction between asbestos and smoking in carcinogenesis.

Chapter 7 details the thesis objectives, and the materials used in the research, and Chapter 8 discusses methodology, in both general and specific terms. The study populations are described fully in

Chapter 9, and the findings are presented in the following chapters.

Discussion, synthesis and recommendations are in Chapter 14, followed by statements on originality and acknowledgements. The leading data are given in a 350-page Annex which is bound as Volume 2 of the thesis.

Chapter 2

ASBESTOS: FORMS, USES AND HEALTH EFFECTS

2.1 Introduction

According to Friedrichsen (1963), the word *asbestos* is from the Latin *absestus* itself from the Greek *a-* (not) with *sbestos* (quenchable). It was certainly in English use by the early 18th Century, and has commonly been employed as a collective term for a wide variety of minerals composed of silicates of magnesium and iron.

The fire-resistant properties of asbestos were known to the ancient Romans, as is clear from the account by Herodotus, in 450 B.C. (quoted by Hunter, 1975, p. 972), of its use in the enshrouding of corpses before cremation to facilitate collection of ashes for burial. This may be the reason for another Latin word for the mineral, *amiant(h)us* (cf. the French *amiante*), literally without miasma, or undefiled, incorruptible. Several classical writers appeared to have been referring to one of the asbestiform minerals, particularly in its use for lamp wicks; the flames of ancient temple lamps were kept replenished with oil so that they would never be extinguished, and this is thought to be the origin of the term unquenchable. These early uses must have involved spinning and weaving, and there is some evidence that cloth made with a mixture of asbestos and vegetable fibre was

used to deaden the sounds of tree-felling in Roman times. Thereafter, there were occasional references to asbestos, for example by Marco Polo (around 1250 A.D.), by Dr. Robert Plot (in 1686) and by Benjamin Franklin (in 1725), this last probably being to asbestos from Quebec (*Asbestos*, 1970; Zussman, 1972). However, much the earliest reported use was in Finland, described by Dr. L. Noro and by Dr. R. Kiviluoto (quoted by Gilson, 1965); Seaton (1975) states that fibres of the indigenous Finnish type of asbestos have been found in the clay of pots made in Finland four thousand years ago, having been added presumably to strengthen the final article.

2.2 Forms and supplies of asbestos

Asbestos has been defined variously. Statements by Hendry and Gaze, at the 1964 Conference on Biological Effects of Asbestos held by the New York Academy of Sciences, that the word asbestos was "a broad term embracing a number of fibrous mineral silicates that differ in chemical composition" and that it was "used to describe any mineral that breaks down into fibres when it is crushed or processed" were echoed by Zussman (1972) who wrote that asbestos was the name for "a mineral which is made up of fine fibres and which is resistant to high temperatures". However, in a 1970 publication, *Asbestos* magazine stated that the term "is not the name of a distinct mineral species but is a commercial term applied to fibrous varieties of several minerals differing widely in chemical composition, the fibres being diverse in length, strength, flexibility and consequent usefulness". More recently, in a report (Ward, 1977) of the International Agency for Research on Cancer (IARC) Working Group on the Evaluation of the Carcinogenic Risks of Chemicals to Man: Asbestos, the use of asbestos

as a generic term is confirmed, but it is also stated that current usage of the term is restricted to six specific naturally-occurring mineral silicate fibres. In fact, commercial use is almost entirely of only four of these fibres: chrysotile, crocidolite, amosite and anthophyllite.

Asbestos is so invaluable because it is made up of fine fibres which are flexible, of great tensile strength, and resistant to high temperatures; they provide good acoustic, electrical and thermal insulation and, to varying degrees, resist corrosion (Zussman, 1972). The three or four commercially important types of asbestos differ in physical properties and in chemical composition and in their health effects.

Chrysotile, or white asbestos, makes up the bulk of world production and use, about nine-tenths in 1977. The fibres are fine, highly flexible and have good heat resistance, while the long fibres can be spun easily into textiles (*Asbestos*, 1970); Hendry (1965) adds to these properties tensile strength, absorption and filtration, stating that in combination they place chrysotile in a class by itself as a mineral of "unparalleled properties". This form of asbestos is a mineral of the so-called serpentine group, and contains mainly magnesium oxide in addition to silica. Most of it is produced in Russia and Canada, but Ward (1977) mentions half-a-dozen other countries where comparatively small deposits are exploited.

Crocidolite, or blue asbestos, and *amosite* are both of the amphibole group of minerals, which are more brittle and of harsher texture

than serpentine fibres; their main chemical constituents in addition to silica are ferrous and ferric oxides. These forms of asbestos now come only from South Africa, although small amounts of crocidolite used to be mined in Australia and Bolivia, while India is about to produce a fibre very similar to amosite (which is a name based on the initial letters of the Asbestos Mine of South Africa where it was first mined) to be called "mysorite" (Ward, 1977). *Anthophyllite* is another amphibole, which used to be produced and used almost exclusively in Finland; according to Ward (1977), production in Finland ceased in 1974. In this form of asbestos there is more silica than in chrysotile, less magnesium oxide and more ferrous oxide.

The modern asbestos industry dates from the discovery in the 1870s of large deposits of fibre in Quebec and Russia (Bogovski *et al.*, 1973, p. xiii); the Canadian and Russian form of asbestos is chrysotile. Slightly later came the commercial exploitation of the three amphibole fibres, crocidolite, amosite and anthophyllite. The Quebec Asbestos Mining Association (QAMA, 1978a) has kindly provided annual figures of asbestos shipments from 1878 (50 short tons) to 1977 (1,289 thousand short tons). Production in Quebec for each decade of the hundred years' existence of this industry, in millions of short tons, was:-

1878-87	0.015	1928-37	2.345
1888-97	0.101	1938-47	4.492
1898-1907	0.490	1948-57	8.771
1908-17	1.267	1958-67	11.449
1918-27	2.075	1968-77	13.399

Quebec has always produced the vast bulk of Canadian asbestos (82.1 per cent of the total production in Canada of 16.311 million short tons in the decade 1968-77). The other provinces that produce asbestos, all chrysotile, are the Yukon territories (109.2 thousand short tons in 1977), British Columbia (103.5 thousand tons), Newfoundland (71.2 thousand tons) and Ontario (16.4 thousand tons). Until recently, Quebec also produced the bulk of the world's total supplies; according to the IARC Working Party on the Evaluation of the Carcinogenic Risk of Chemicals to Man: Asbestos (Ward, 1977), who had to assemble data from several sources, Canada's share of world production was 45 per cent in 1960. However, this share had fallen to 29 per cent in 1976 (Ward, 1977) and was 27.4 per cent in 1977; Quebec's share in 1977 was 22.3 per cent (QAMA, 1978b). The USSR is now the main producer of asbestos, having increased its share of world production from 29 per cent in 1960 to 44 per cent in 1976 (Ward, 1977); in 1977, Russia produced 2,596 thousand short tons, all chrysotile, 44.8 per cent of the total, 5,790 thousand short tons (QAMA, 1978b).

It is difficult to obtain a direct statement of how much of each fibre is produced, but it seems that crocidolite and amosite are nowadays mined only in South Africa, which in 1977 produced 750 thousand short tons of all forms of asbestos, while anthophyllite production in Finland ceased in 1974 (Ward, 1977; QAMA, 1978b). As about nine-tenths of the current South African labour force produce amphibole (Gibbs and DuToit, 1978), the proportion of chrysotile in the grand total must be close to ninety per cent. The countries that mined chrysotile in 1977 were, in addition to Russia and Canada, China (220 thousand short tons), Cyprus and Italy (a total of 330 thousand tons),

with the USA, South America, Australia and "other countries" accounting for 105, 80, 75 and 45 thousand short tons, respectively (QAMA, 1978b). Small amounts of fibre have been produced in the past in Corsica (chrysotile) and in Australia and Bolivia (crocidolite); some limited amounts of another asbestiform mineral, tremolite, have been mined in the USA and the Far East (Ward, 1977).

The four main types of asbestos fibre differ greatly in their chemical composition, as shown in the x-ray spectra (after Dr. Fred Pooley) in Figure 2.1, which are in close conformity with the analyses given by Gaze (1965). All types of fibre contain silica (Si), but there is less in chrysotile (40 per cent) than in the amphiboles (around 50 per cent in crocidolite and amosite; 57 per cent in anthophyllite). The main constituent of chrysotile is 42 per cent of magnesium oxide (MgO), but that forms only a small part of crocidolite (1 per cent) and amosite (6 per cent), although up to 29 per cent in anthophyllite. On the other hand, iron is scarce in chrysotile, ferrous oxide (FeO) and ferric oxide (Fe₂O₃) totalling less than 3 per cent, but common in the South African amphiboles (around 40 per cent) and intermediate in anthophyllite. Water of crystallization is 14 per cent of chrysotile but only 2 per cent of the amphiboles.

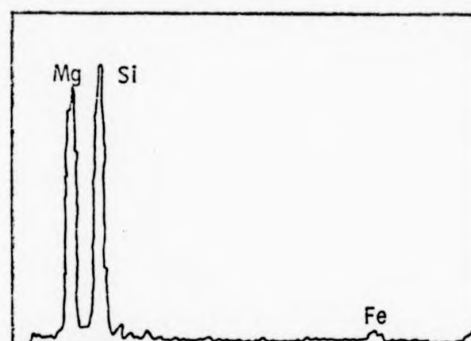
2.3 Uses of asbestos

At least three thousand uses of asbestos have been identified (Rosato, 1959); a short list of over 150 is given by *Asbestos* (1970). Raw asbestos is used for the "rovings" from which all spun and woven textiles are made; in felts, paper, millboard and wall board; for reinforcement of cement products; for thermal, electrical and acoustic

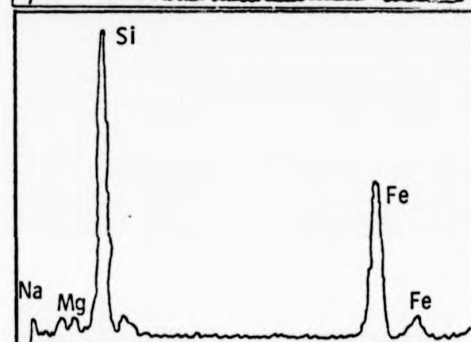
Figure 2.1

X-RAY SPECTRA

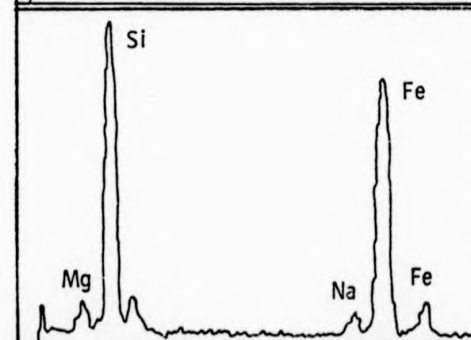
Chrysotile



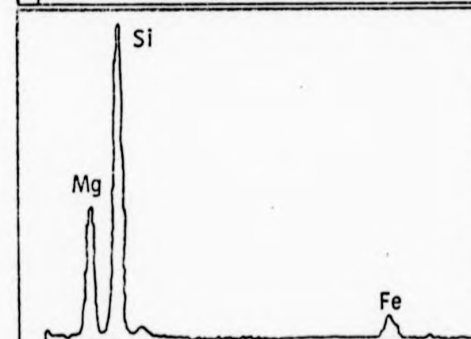
Crocidolite



Amosite



Anthophyllite



insulation; for friction materials and filtration media; for fireproofing and other protective clothing. Asbestos yarn is used for cloth, electrical tape, brake linings, clutch facings, gaskets, rope, twine, sewing thread, wicks, etc. The cloth woven from asbestos has many uses, not least because of its strength - clothing, draperies, mailbags, ironing boards, for example. Asbestos millboard, being fireproof, has a large number of applications in industry and building; here, too, asbestos-cement sheets, flat and corrugated, and asbestos-cement wall boards are popular. Asbestos-cement pipe is used for flues and chimneys in the home and elsewhere, and for high and low pressure systems.

Since the introduction of asbestos into the Paris Métro (1903) to prevent the repetition of a disastrous fire, and particularly in the interior of RMS Queen Mary (1932) to prevent the spread of any possible fire, its pre-eminence as a fire-resistant material has been recognized. It is used for firefighters' suits, helmets, ropes and sheets. With the introduction (1912) of a method of constructing seamless asbestos-cement pipes, such pipes have been very widely used for a multitude of purposes, and asbestos itself is used for jointing and lagging steam pipes, etc, and for many other forms of heat insulation. It can be exploited in the form of building materials such as tiles - for roof or floor - and even linoleum, for cements and cement sheets, and for fireproof panels, including theatre safety curtains. Because it is acid-resistant, asbestos is used for filter cloths, linings for certain chemical vessels, valve packings and gaskets. Re-inforced with wire threads, asbestos is the major ingredient of brake linings and clutch facings. On top of these largely industrial uses, asbestos

has many domestic applications, for example in ironing boards, oven cloths, cooking mats, and other kitchen materials. Finally, it has been a favourite material in the "Do-It-Yourself" market.

Although about ninety per cent of asbestos usage is of chrysotile, the other forms have often been specified for particular purposes. One set of examples is given in an important section of the doctoral thesis of Surgeon Commander P. G. Harries (1971). Until 1950, the Admiralty specified crocidolite for certain materials used in the insulation of machinery in steam-propelled warships. With higher steam temperatures after 1950, large pipe sections, almost wholly of amosite fibre, were tried but found less efficient than had been expected. More recently, pipe lagging has been with calcium silicate bound by amosite, the binder amounting to 12 per cent of the material. Further, until the late 1950s, insulation of steel decks and hull was mainly with crocidolite. One other specified use of crocidolite was for the filter pads in service gas masks in World War II, while chrysotile was used for civilian masks (Jones *et al.*, 1976; McDonald and McDonald, 1978; Dr. J. C. Gilson, personal communication).

Perhaps the most important present-day use of asbestos is in cement products, and particularly for asbestos-cement pipes. Here, fast drying is essential in manufacture, especially for the pipes of largest diameter, and this process is greatly accelerated by a mixture of about one-sixth of crocidolite; see below. Certain other processes have been devised for specific amphibole fibres and cannot easily be adapted to the exclusive use of chrysotile.

The IARC Working Group (Ward, 1977, quoting Clifton, 1974) gives the following distribution of asbestos use, by type, in the USA for 1974 (*sic*):-

Chrysotile	720.8 million kg	94.5 per cent
Crocidolite	33.8 "	4.4 "
Amosite	8.4 "	1.1 "
Anthophyllite	1.0 "	0.1 "
	<hr/> 763	<hr/> 100

Most of the crocidolite (33 million kg) was used for asbestos-cement pipes, but accounted for only one sixth of the asbestos used for this product. The amosite was used mainly for asbestos-cement sheet (3.9 million kg), thermal insulation (1.6 million kg) and roofing products (1.5 million kg), but chrysotile was still the most commonly used fibre for these products, accounting for 95.3, 82.5 and 98.5 per cent, respectively, of the asbestos in each. QAMA (1978b) provide approximate fibre content in various products, as follows:-

Asbestos cloth and yarn	85-90 per cent by weight		
Asbestos papers (felts)	80-90	"	"
Asbestos water-proofing and anti-leak joints	50-70	"	"
Woven friction material	70	"	"
Moulded friction material	50-60	"	"
Asbestos pipes	16	"	"
Asbestos finished sheets	10-15	"	"
Asbestos-vinyl tiles	8-14	"	"

2.4 Geology and exploitation

Zussman (1972) concluded his article on the nature and history of asbestos with the statement that: "Even after many decades of research, the mode of growth of natural asbestos fibres remains largely a matter of conjecture". Certainly, the geology of the asbestos-bearing rocks and their overburden is too complex to fall within the scope of this thesis. However, a few facts are given below, taken from a 32-page guide to the geology of the mining region of South-Eastern Quebec, with more than a dozen maps, and many references (QAMA, 1972). The Quebec deposits of chrysotile lie in a belt a few miles wide and about 120 miles long. Chrysotile occurs mainly as cross fibre, but also as slip fibre and mass fibre. "Cross fibre occurs in veins with fibres occupying a position somewhere between normal and sharply oblique to the vein walls, whereas slip fibre is a stress mineral occurring as a coating on slip planes and orientated parallel to the direction of slip. Mass fibre is present in the ore of a few mines as aggregates of unoriented or semi-oriented leaves or bundles of chrysotile. At some locations the rocks have been completely or nearly converted into mass fibre." At Asbestos, Quebec, there is one mine (and a small factory), which has been in operation since 1881, producing mainly cross fibre but some mass fibre from rock that may contain as much as 50 per cent chrysotile. The present rating of this mine is 600 thousand tons of fibre a year. In the Thetford Mines area, there are presently four mines; deposits are made up principally of cross fibre, but an appreciable amount of slip fibre ore is being recovered. At one location, there were three deposits, one now worked out, one in production and the third not started. "Although difficult to explain, one interesting aspect of the fibre quality ... is the increasing

'softness' of the fibre with depth ... " Finally, much of the host rock is itself "serpentized".

Ore, whether from an open pit or underground mine, often contains less than ten per cent asbestos, with ninety per cent or more waste rock. At the mine in Asbestos, Quebec, fifteen tons of ore are crushed to produce a ton of commercially disposable asbestos, but the total material moved is more than 60 tons (QAMA, 1972, p. 19). The ore is fed first to ore preparation plants, where it is crushed and separated. The larger fraction is further sorted by hand, but the smaller is first dried and then passed to mills in which operations are carried out in cycles of crushing, screening and then lifting by air (Lincoln, 1972). Figure 2.2, taken from Gibbs and Lachance (1972), gives a schematic illustration of the process, in principle.

2.5 Dust exposure and inhalation

Thus, milling is essentially a dusty operation, in which suppressive measures relying on wetting have not so far proved feasible. Mining, contrary to some expectations, is generally less dusty (Gibbs and Lachance, 1972). However, many jobs involving the handling of asbestos or asbestos products were, until quite recently, very dusty. Up to about 1950, baggers in the Quebec mills were exposed to concentrations of over 200 million (respirable) particles per cubic foot (of air), or 200 mpcf, and at that time the average concentration to which millers were exposed was approximately 75 mpcf (Gibbs and Lachance, 1972). In naval dockyards, many of the various processes involving asbestos were very dusty, and Harries (1971, p. 30) stated that "men are described as emerging from the compartments covered from head to

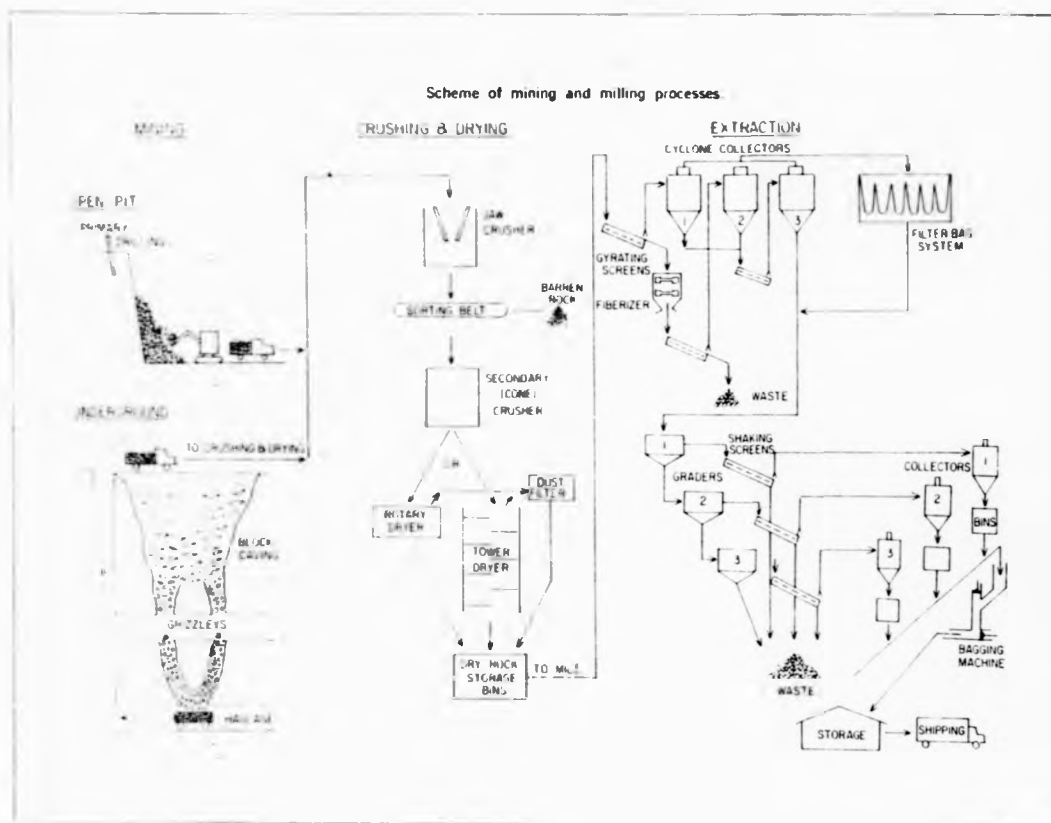


Figure 2.2

SCHEME OF MINING AND MILLING PROCESSES

foot in dust", and also that "although most of the fibre was blue, amosite fibre was used occasionally and was disliked because it was more dusty". In textile factories, carding has always been particularly dusty: Knox *et al.* (1968), reporting on a factory in Rochdale at which "steps [had been] taken to reduce exposure ... since the introduction of the Asbestos Industry Regulations in 1931", quoted yearly mean dust levels as high as 32 mpcf as late as 1952. Enterline *et al.* (1972b) reported historic dust levels (i.e. before 1947) in an American asbestos plant, in New Jersey, "in excess of 50 mpcf".

These figures of dust concentrations are, of course, meaningless in isolation - this matter is discussed in a later chapter - and, because they had been obtained by different technologies, they are not on a comparable basis. However, what is clear is that dust concentrations were, in each of the cases cited above, about two orders of magnitude worse than levels in the early 1970s, although these levels themselves were still much higher than today's "standards". The 1931 Regulations referred to by Knox and his colleagues will be mentioned later; at this point, it is only necessary to point out that they introduced dust suppressive measures in 1933. Thus, before that date dust concentrations were surely at least another order of magnitude worse than in the 1950s. Newhouse (1973a) cites anecdotal evidence to this effect in British factories, and Gibbs and Lachance (1972) corresponding evidence concerning Quebec mines and mills.

Such an insult to the lungs might well be expected to cause severe disease. Indeed, in *De Re Metallica*, published in 1556, Agricola (1494-1555) commented " ... the dust, which is stirred and

beaten up by digging, penetrates into the windpipe and lungs, and produces difficulty in breathing and the disease which the Greeks called asthma". Hunter (1975), who quotes this comment on p. 27, later (p. 918) added "It was here [Joachimsthal, in Bohemia] that Agricola strongly advocated the ventilation of mines, for he knew that dust entering the lungs caused disease associated with dyspnoea, and he spoke of corrosive dusts which ulcerated the lungs, producing consumption." Hunter (p. 27) considers Agricola's accounts of miners' ailments as rambling and without precision, and that the idea of diseases specifically caused by particular occupations had not in Agricola's day been conceived. Hunter believes that the conditions being described more than 400 years ago probably included silicosis, tuberculosis and lung cancer. Nevertheless, it would appear that Agricola was the first to recognize a "pneumoconiosis", albeit in hard-rock miners extracting gold and silver.

This term, coined as "pneumonokoniosis" by Zenker in 1876, is another collective noun, meaning literally lung-dust-condition, or better a health effect arising from the inhalation of dust. VanOrdstrand (1977) lists some 26 pneumoconioses, providing a personal classification into (A) the benign, (B) those that are usually reversible and (C) those which may be disabling and even fatal. It is unlikely that this grouping would be generally accepted by those working in this field, but there is little doubt that *asbestosis* may indeed be disabling and may lead to premature death; see below.

However, before reviewing the effects on health of the inhalation of dust, it is necessary to consider what happens to the dust itself.

This is a matter of great complexity, which has been the subject of theoretical and experimental investigations since the 1930s, but about which knowledge is still not complete. Reliance has to be placed on morphological and pathological evidence, which can, of course, be quite misleading. Experiments in man may be not only dangerous but unrewarding, because the present concern should be to examine in what *practical* circumstances particular amounts of fibre are retained in the lung and how these amounts differ and, even more difficult, why. For the present purposes, a very simplified statement must suffice: it is based on the following references:- McDonald, Gibbs *et al.* (1972); Muir (1972); Timbrell (1973); and Morgan (1975).

There appear to be two generally agreed facts. First, only those particles or fibres less than about ten micro-metres (μm) enter the respiratory system, and most of the larger even of this size are trapped in the nose or the upper regions of the main respiratory tract. It is also likely that the curly fibres of chrysotile have greater difficulty in penetrating deeply, because of interception in the branching respiratory passages, than the more rectilinear fibres of the amphiboles. Further, dust deposition is a complex process, involving sedimentation, inertial impaction and diffusion, each element of which depends on the sizes, shapes and density of the particulate matter, its concentration, electric charges and growth of hygroscopic particles due to humidity, and to ambient temperature and humidity which may reach extremes in some occupational environments, particularly mining. Thus only the very fine fibres penetrate to the alveoli, and the shortest of these to the periphery. The second fact is that a

high proportion of those fibres or particles that do penetrate to the small air cells is eliminated by ciliary action and mucous escalation, to be swallowed and excreted *via* the gastro-intestinal tract. This process of elimination is usually highly efficient, and indeed is thought to be improved when heavily loaded. However, it may not be able to cope with truly massive quantities of retained particulate matter. Further, the macrophages, which have to engulf the fibres before they are eliminated are incapable of dealing with long straight fibres, common in crocidolite, and particularly in amosite.

The amount of fibre retained in the lung is an extremely small proportion of that inhaled, and that proportion may well vary, not only because of differences in factors already discussed, but also with factors of human variation. Such factors may be physiological or immunological; they may be altered by smoking habit or by respiratory disease, either acute or chronic; and they almost certainly include differences in breathing patterns, through nose or mouth, and in rate and depth of breathing dependent on physical effort.

Chrysotile fibres are more soluble than amphiboles and this plays an important part in determining what proportions are retained for long periods. Retained chrysotile fibres may break up into even smaller "fibrils", detected in the lung by electron microscopy *post mortem*. However, the fibres of crocidolite appear to retain their original form, and are often retained indefinitely, being easily recognized at autopsy. Retained fibres may migrate within the parenchyma, or to pleura or even peritoneum.

Figure 2.3 gives copies of electron micrographs of respirable fibres, taken from Timbrell (1973), who commented on the curly morphology of chrysotile fibres compared with the rectilinear shapes of the amphiboles, and that the diameters of crocidolite were of smaller order than those of anthophyllite, with amosite in between, and that this was a characteristic of such fibres from Cape Province, Finland and the Transvaal, i.e. whence all commercial supplies now come. He also emphasised the fragmentation of the chrysotile fibres, longitudinally, into fibrils of very small diameter, about 0.03 μm .

2.6 Pulmonary fibrosis; asbestosis

Those who have been heavily exposed to asbestos dust may develop asbestosis. Harries (1971, p. 11) reports Burton Wood's 1929 findings in 15 cases of asbestosis examined for symptoms, signs and x-ray changes. "The most important symptom was dyspnoea, which was progressive, and in the later stages of disease, extreme. Cough was often slight, and was a variable symptom. He noted a reduced chest expansion, cyanosis and finger clubbing often occurred. Dry crackling adventitious sounds were present, chiefly in the bases and superficially in the axillae. He thought the latter sound might have a pleural origin. The first patient described in the series is reported as having a vital capacity of 1,600 cc and this is the first report of a lung function test in asbestosis. The x-ray films were described, and Burton Wood mentioned that although some of the cases showed a 'ground glass' appearance over the lower zones, a fine mottling was seen on closer inspection. Basal pleurisy was seen in many films and also thickening of the apical pleural cap."

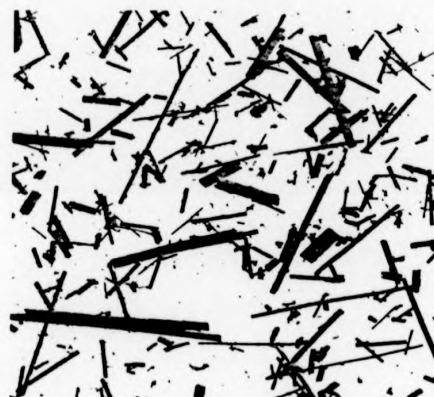
Figure 2.3

ELECTRON MICROGRAPHS OF ASBESTOS FIBRES

CROCIDOLITE



AMOSITE



ANTHOPHYLLITE



CHRYBOTILE



10 μ m

As a result of a report in 1928 of an asbestos worker with pulmonary fibrosis for which no occupational or infective cause, other than asbestos, could be found, Merewether and Price (1930) investigated, for the Factory Department of the Home Office, the effects of asbestos dust on the lungs (Harries, 1971, p. 11). They showed that, of 363 asbestos textile workers examined, 95 (over a quarter) had definite pulmonary fibrosis considered due to asbestos dust. These workers found a correlation between the incidence of fibrosis and the duration and intensity of dust exposure. Radiological examination of 133 workers revealed signs of diffuse fibrosis in 62 (nearly half), while radiological changes were suggestive in a further 25. Harries comments that radiographic technique was probably such as to lead to under-estimation of the prevalence of changes, but does not comment on how the workers subjected to x-ray examination were selected for this purpose. Merewether and Price found no particular tendency for respiratory tuberculosis to be present in the asbestos workers, with or without fibrosis.

The report of Merewether and Price suggested not only a dose-response relationship, but also that the interval between start of exposure and development of definite disease depended on the dust concentration. The latent period was as short as seven years in continuous high exposure, but could be as long as 25 years in lower concentrations. It was clear that dust suppression was needed if the disease was to be prevented. Merewether and Price further reviewed the dust concentrations in the various asbestos textile processes and made recommendations as to suitable methods of dust suppressive measures. It was these measures that formed the basis of the Asbestos Industry

Regulations 1931, in the United Kingdom. These were not implemented until 1933, but they included periodic medical supervision of persons working in certain prescribed asbestos occupations, while asbestosis was recognized as a condition covered by the Workmen's Compensation Acts.

The earliest studies of asbestos-related disease in the United States appear to have taken place in the mid-1930s, as described by Ayer *et al.* (1965), and a Threshold Limit Value was set "many years ago", according to Schall writing in 1964, by the American Conference of Government Industrial Hygienists, based on the findings of Dreessen *et al.* (1938). This standard was endorsed by the ACGIH in 1964, although Schall (1965) had some severe criticisms of it.

2.7 Diagnosis of asbestosis

Although it is nearly fifty years since these findings were presented, there is still no generally agreed definition of asbestosis. This is despite the introduction of a new international classification of radiographs of the pneumoconioses (to be discussed fully in a later chapter), which was prepared over the years 1966-71 with asbestosis well in mind; it had not been considered in the earlier ILO classifications. In 1971, Harries (p. 24) commented that there was disagreement over the presence and significance of the various symptoms and signs, including the radiological and lung function changes; in particular, the importance of pleural changes was not generally agreed. Harries felt that the most acceptable consensus of opinion was that asbestosis is a *progressive* pulmonary fibrosis resulting from exposure to asbestos dust, accompanied by fibrotic changes in the pleura which

may develop areas of calcification. He went on to state that little advance had been made in the matter of *early* diagnosis of asbestosis, pointing out that it still required intelligent assessment of all the relevant data. Lewinsohn (1977) stated that "asbestosis is still the *earliest* lung disease resulting from exposure to [asbestos] and its incidence in an exposed population is the most useful indicator of the degree of dust control exercised over a period of time". These views are not entirely compatible; the use of the terms "progressive" and "earliest" suggest different attitudes towards the condition. (The italics in this paragraph and the next are mine.)

Lewinsohn (1977) also stated that, for him, "the diagnosis [of asbestosis] depends upon: (1) An adequate occupational exposure history. (2) Physical signs of pulmonary fibrosis. (3) *Progressive* radiological changes. (4) Confirmatory measurements of altered lung function". The physical signs he was referring to were basal rales and finger clubbing, and he well recognized the subjectivity of their assessment. He made the point that the presence of asbestos bodies and fibres in sputum were of little importance in that they could only confirm exposure, which should already have been ascertained as part of the history. It was, of course, essential that the history should include all exposure, including any that may have occurred during, for example, home repairs. Lewinsohn did not explain what he meant by "progressive" x-ray changes. Further, his emphasis on the confirmatory nature of altered lung function is not echoed by all other workers. Thus, Keatinge (1973), reviewing the work of Ghezzi *et al.* (1972), stated that "even in the absence of radiographic changes, clinical examination and lung function tests will provide enough evidence to

demonstrate that the patient has been exposed to asbestos in the past". In this context, the evidence, concerning a specific patient, is required presumably for purposes such as compensation.

2.8 Is asbestosis progressive?

As to the presumed progressive nature of asbestosis, Gilson (1973) reported to the Working Conference held at the IARC, Lyon, that little progress had been achieved in the investigation of the effects of the removal from further exposure to asbestos dust. It had been one of the recommendations of the Union Internationale contre le Cancer (UICC) Working Group in 1964 that it was important to establish the subsequent morbidity and mortality from asbestosis, and the mortality from cancers associated with exposure to asbestos, in population groups no longer exposed to the dust. As a first step, Professor McDonald's team at McGill University assembled a group of 86 ex-employees of the Quebec chrysotile production industry; they were men born in the years 1901 through 1920 who had left the industry in the period 1950-61 and had been x-rayed before leaving. These men were x-rayed again in 1972, and seven separate assessments were made of the film pairs, all by experienced readers. Parenchymal change was recorded in at least four assessments for eight of the 66 men who had had substantial exposure before leaving, but for none of the 20 with only slight exposure. It was concluded (Becklake *et al.*, 1978) that the parenchymal changes observed after leaving the industry were attributable to the earlier occupational exposure to chrysotile; these changes were mainly in the nature of "attacks" rather than "progression". Pleural change was recorded for 15 of the 66 with heavier exposure and for 4 of the other 20, very similar proportions.

2.9 Asbestosis and mortality

Although there are still problems over definitions and whether or not asbestosis is essentially progressive, it remains clear that in those who have been heavily exposed to asbestos dust, there may be respiratory symptoms (usually breathlessness, first only on exercise, and later more severe, even seriously disabling), impaired lung function (particularly reduced Forced Vital Capacity, or FVC, and transfer factor), basal rales, finger clubbing, and changes on the chest roentgenogram; one, several or all of these signs and symptoms may be present, but there are also many heavily exposed workers who show none of them. X-ray changes include nowadays many that were incorporated into the international classification for the first time in 1968, and incorporated into the ILO U/C (1971) classification when this eventually appeared.

Asbestosis can undoubtedly lead to premature death. Indeed, the first description of the disease process, in 1906 by Dr. Montague Murray at the Charing Cross Hospital in London, was in an asbestos textile worker, with incapacitating breathlessness, but few other physical signs, who died at the age of 33; at autopsy, there was widespread pulmonary fibrosis, with no evidence of tuberculosis, together with marked pleuritic adhesions. "This patient was the sole survivor of 10 men working in the carding room when he commenced work [there]; the others had all died about the age of thirty" (Harries, 1971, p. 11). The second *post mortem* to direct attention to the possibility that silicates might cause extensive fibrosis was not until 1924, when Cooke demonstrated what have come to be called "asbestos bodies" in the lungs of a young tuberculous female textile worker (McVittie, 1965).

Three years later, according to McVittie, "a whole new literature relating to asbestos appeared in Britain", and in 1933, Merewether (cited by Harries, 1971, p. 13), while pointing out the difficulty of making the diagnosis of asbestosis, noted its insidiousness and reported the average age of death for men with asbestosis as 40.8 years, compared with 54.1 years for those with silicosis. Of the 100 men with asbestosis discovered in a Home Office enquiry in 1928, seventeen had died, ten with asbestosis, six from asbestosis with tuberculosis and one with asbestosis and carcinoma of the pancreas.

2.10 Lung cancer

Primary carcinoma of the lung has often been recorded in asbestos workers, frequently in association with pulmonary asbestosis. For example, Doll (1955) concluded that the average risk of cancer of the lung in workers who had been exposed to asbestos dust for twenty years or more was of the order of ten times that experienced by the general population. Although Braun and Truan (1958) criticised Doll's findings and "found no unusual risk to asbestos miners in the province of Quebec", their own conclusion was hardly justified; see below. Again, McCulloch in 1959 reported lung cancer in 65 out of 365 deaths (18 per cent) during 1924-55 in which *post mortem* had confirmed the presence of asbestosis (Harries, 1971).

McDonald (1973) reviewed cancer in chrysotile mines and mills, pointing out that Braun and Truan (1958; just referred to) had observed at least nine lung cancer deaths within a specified cohort, compared with six expected from Provincial rates. McDonald also referred to the findings of Kogan *et al.* (1966) in a ten-year study of

mine and mill workers from Sverdlovsk, a large Russian city on the eastern edge of the Ural mountains and fairly close to the world's most extensive chrysotile deposits, at Asbest: although materials and methods were not fully described, it was reported that mortality from lung cancer was increased by factors of 1.9, 2.3 and 3.1 for miners, factory workers and millers, respectively. The investigation of mortality in the Quebec chrysotile mines and mills carried out by McDonald and his colleagues has been reported *seriatim* (McDonald *et al.*, 1971; 1973; 1974; Liddell, McDonald and Thomas, 1977; McDonald and Liddell, 1978; and in preparation, but cited here as McDonald *et al.*, 1979). From the start, excess lung cancer mortality has been shown among the male workers. This study is particularly important because of its size (now 4,500 deaths in a defined cohort of nearly 11,000 men - and 440 women), because of the "purity" of the exposure, because it includes workers with very little exposure as well as those with heavy exposures, and because quantitative estimates of dust concentrations have been made. There appears to be a clear relationship between excess lung cancer mortality and total dust exposure.

An important co-carcinogen is, of course, cigarette smoke. The latest report by McDonald *et al.* (1979) will show that the data fit quite well a multiplicative model of risks, in which the two agents (asbestos dust and cigarette smoke) act in such a way that "... addition of the second agent produces an effect which is proportional to the effect of the first. If smoking alone increases the natural incidence of lung cancer, say, 10 times (i.e. the relative risk due to smoking alone is 10) and asbestos alone increases it three times, the lung cancer incidence in those exposed to both asbestos and smoking

will be equal to $10 \times 3 = 30$ times the natural incidence". This quotation is from Saracci (1977), who was analysing the epidemiological evidence on the asbestos-smoking interaction, and concluded that this model stood as the most plausible interpretation of the interaction. The data from Quebec (not available to Saracci) suggest that exposure for 50 years to concentrations averaging one mpcf are roughly equivalent in their effect of generating lung cancer to the smoking of three cigarettes a week (McDonald and Liddell, 1978).

There have now been many investigations among other groups of workers, in all of which excess lung cancer mortality has been observed in comparison with expectations based on national, state or similar reference populations. There appears little doubt that all forms of asbestos can produce not only fibrosis but also lung cancer. However, Wagner *et al.* (1971), reviewing the epidemiology of asbestos cancers, stated that "The epidemiological evidence suggests that the use of chrysotile asbestos with efficient suppression carries only a small risk. The use of crocidolite should be avoided wherever possible. The position of amosite is probably intermediate, but dust control should be at at high standard". Enterline and Henderson (1973) were a little sceptical, although their own review tended to support the gradient in carcinogenicity indicated by Wagner and his colleagues. Further confirmation comes from a study by Weiss (1977).

Because the importance of fibre type cannot be overemphasised, an up-to-date review of the evidence on relationships between dose of asbestos dust and response in the form of lung cancer mortality is given in Chapter 6.

2.11 Mesothelioma

Although first suggested only in 1960, by Dr. J. C. Wagner and his colleagues, in South Africa, it is now generally accepted that asbestos dust can cause mesothelioma, i.e. malignant mesothelial tumours of pleura or peritoneum. This is an extremely rare tumour with an incidence around two per million population each year in many countries of the world (McDonald and McDonald, 1977). However, the incidence is often higher in cities with dockyards, and higher still in working populations exposed to asbestos. Important excesses occur in Turkey, particularly in two villages in central Anatolia, Karain and Tuzköy, where Baris *et al.* (1978) have reported extremely high incidence of mesothelioma, consistent with environmental exposure to a carcinogen since birth, although there are no asbestos deposits in the neighbourhood. Mineralogical studies have suggested that zeolite minerals may be the causative agents, and Pooley (1978) has shown that the zeolites near these villages, but not elsewhere in Anatolia, are of similar sizes and shapes as the fibres of crocidolite; see Figure 2.3.

McDonald and McDonald (1977) present proportional mortality rates for lung cancer and for mesothelioma from the main published cohort studies of male asbestos workers (Table 2.1). After allowance for differences in the general incidence of these diseases in the countries concerned, these authors commented as follows: "The findings for insulation workers, mainly obtained by Selikoff and his colleagues (1973), but supported by the studies of Elmes and Simpson (1971) in Belfast and Kleinfeld and others (1967) in New York State, were all very similar. Regardless of age, type of work or duration of observation period, about 20 per cent of deaths in insulation workers were

Occupational group	Location	Period	Deaths: all causes
Insulators			
All types	NY & NJ	1943-72	421
All types	US & Canada	1967-72	1,092
Construction	US & Canada	1967-72	446
Shipyards	US & Canada	1967-72	34
All types	NY	1945-65	46
All types	Belfast	1940-66	98
Asbestos factory			
Textiles	Rochdale	1916-67	125
Mixed products	London	1931-70	350
Mixed products	PA	1938-64	330
Mixed products	Cardiff	1936-62	133
Amosite insulation			
materials	NJ	1941-71	484
Mining and milling			
Chrysotile	Quebec	1936-73	3,749
Chrysotile	N. Italy	1932-70	270
Anthophyllite	Finland	1936-67	216
Talc & tremolite	NY	1940-65	91

Table 2.1

PROPORTIONAL MORTALITY FROM LUNG CANCER AND MESOTHELIOMA
(McDonald and McDonald, 1977, Table 12)

Per cent lung cancer	Per cent mesothelioma	Per cent pleural
20.0	7.6	25
19.5	7.1	34
17.7	5.2	43
26.5	8.8	66
21.7	6.5	33
24.5	7.1	57
17.6	3.2	100
20.6	6.9	38
10.6	2.4	0
8.3	0.8	100
15.1	1.4	43
5.7	0.2	100
2.2	0	-
9.7	0	-
9.9	2.2	50

caused by lung cancer and a third as many more by mesothelioma, predominantly of the peritoneum. The mortality of factory workers was more variable; the lung cancer ratios were generally lower and there were fewer mesotheliomas. The London factory investigated by Newhouse (1973b) which used chrysotile, crocidolite, and amosite seems to have fared worse than the predominantly chrysotile factories in Rochdale studied by Knox and others (1968), in Lancaster, Pennsylvania by Mancuso and El Attar (1967), and in Cardiff by Elwood and Cochrane (1964). The amosite plant in Paterson, New Jersey surveyed by Selikoff *et al.* (1973) occupied an intermediate position. In the asbestos production industry, experience was quite different, as shown by our own studies in Quebec and those of Ghezzi *et al.* (1972) in Northern Italy and also those of anthophyllite workers by Meurman *et al.* (1974) in Finland. In all these groups, lung cancer was a less frequent cause of death, and there were few pleural mesotheliomas and none of the peritoneum. This was in line with reports from Kogan *et al.* (1972) in the USSR of a similar moderate increase in lung cancer in the many thousand Russian chrysotile miners and millers, but no evidence of mesothelioma, though cases might have been missed."

Some more recent information follows. McDonald and his colleagues have discovered only eleven deaths due to mesothelioma among over 4,500 deaths in the years 1911-1975 in a defined cohort of more than 11,000 workers in the Quebec chrysotile production industry, some of whom were exposed very severely, with accumulated dust exposures amounting to over 4,000 mpcf.years, the equivalent of fifty years employment in dust concentrations averaging 80 mpcf. Of the eleven cases, one was a female known to have worked in a gas mask process -

see below - and a second was male employed only for a short time in the same factory at the relevant period. Of the other cases, all male, two were workers at Asbestos and seven at Thetford Mines, where dust concentrations were generally considerably higher than at Asbestos, and where men tended to be employed for longer periods. None of the cases had accumulated exposure greater than 1,000 mpcf.y, but there was some evidence of a dose-response relationship at Thetford Mines. Even here, the proportional mortality ratio (PMR), i.e. seven deaths from mesothelioma among a total of 2,284 deaths, was only 3.1 per thousand.

Selikoff and Hammond (1975) have recently updated three important series: 17,800 insulation workers in the USA and Canada, followed after at least twenty years since first exposure; 623 asbestos insulation workers in New York and New Jersey, followed similarly; and 933 amosite factory workers first employed 1941-45, followed after at least twelve years since first exposure. Deaths from mesothelioma in relation to those from all causes for the three populations were:- 87 in 1,109 (PMR = 78.3 per thousand); 35 in 444 (PMR = 78.8); and 10 in 429 (PMR = 23.3).

Peto *et al.* (1977) and Peto (1978) reported that, in all the workers studied at the factory in Rochdale, there had been some 34 deaths from mesothelioma. Five of these occurred among the 186 deaths (all causes) of workers with at least 10 years exposure, a PMR of 26.9 per thousand. Although most of the fibre used in this factory was chrysotile, some crocidolite has been processed; the amount is reported to be low, but there is considerable evidence (for example from a

former Medical Inspector of Factories) that "blue" asbestos was commonly used there in the 1950s.

Jones *et al.* (1976) and McDonald and McDonald (1978) have demonstrated enormous risks of deaths due to mesothelioma in workers exposed during World War II to crocidolite used in the filters of military gas masks, in England and Eastern Canada, respectively. In the Canadian study, a total of 199 persons had been employed in this process for a maximum of about two years, several at the factory in Asbestos, Quebec. Of the total, 56 were known to have died by the end of 1975; nine of the deaths were from mesothelioma, a PMR of 160.7 per thousand. Seven of the nine mesotheliomas were peritoneal.

All the mesotheliomas among miners and millers in Quebec and among factory workers in Rochdale were pleural, whereas the majority of those in other asbestos employment involved the peritoneum. Peto (1978) developed an argument based on these differences, which leads to incrimination of chrysotile. Undoubtedly, the PMR among Quebec miners and millers is rather higher than in the general population of Quebec, but it is very much less than in those known to have been exposed to amphiboles. Although no great reliance can be placed on the exact values of the PMRs, they do appear to give the order of magnitude of the risks, i.e. 3 per thousand for miners and millers at Thetford Mines; 23 for amosite workers; 27 for Rochdale factory workers; 78 for American and Canadian insulation workers; 104 for Barking factory workers; and 161 for Canadian crocidolite gas mask filter workers. These differences cannot be denied, despite the dismissal by Selikoff and Hammond (1975) of the proposal that "the

specificity for mesothelioma is greater for some kinds of asbestos than for others".

Thus it is difficult not to agree with McDonald and McDonald (1977) that the incidence of mesothelioma in insulation workers may be 100-200 times greater than in the general population, whereas in those engaged in chrysotile production it is perhaps three to six times greater. Indeed, it seems likely, as these workers suggested, that the potential for causing mesothelioma follows a gradient similar to that for lung cancer, *viz.* crocidolite is the worst hazard, chrysotile the least.

2.12 Cancer of the gastro-intestinal tract

Harries (1971, p. 231), in a review of evidence, remarked that several studies of asbestos workers had shown an increased risk of cancer of the gastro-intestinal tract. Bonser and colleagues had reported (1955) four abdominal cancers in 72 cases of asbestosis, and Keal, in 1960, one death from peritoneal neoplasm in 15 male deaths with asbestosis, and 9 female deaths from ovarian or peritoneal cancer in 15 similar female deaths. Mancuso and Coulter (1963) found an excess of peritoneal neoplasms, and Selikoff *et al.* (1964) excesses of the stomach, colon or rectum. Doll, in 1955, and with Knox and co-workers in 1968, showed no excess of cancers other than of the lung, while Meurman *et al.* (1974), studying anthophyllite workers in Finland, reported excesses of lung cancer and asbestosis, but not of cancers of the digestive system.

McDonald (1973), concerned with gastro-intestinal cancer in chry-

sotile miners and millers, reported no excess in Italy, but a slight excess, not always at the same sites, in each of his serial reports from Quebec. The excesses appeared only in those with exposures greater than 400 mpcf.y. In the latest Quebec material (McDonald *et al.*, 1979), case-control studies of all 154 deaths from cancer of the stomach or oesophagus and 88 deaths of cancer of the colon or rectum, each with two controls matched for age and mining district, have revealed that the relative risk for cancer of the stomach or oesophagus was normal for exposures up to 1,000 mpcf.y, but much enhanced at higher exposures. For cancer of the colon and rectum, relative risk was normal in men with exposures up to 300 mpcf.y, and then increased.

It would therefore appear that heavy exposure to asbestos may indeed lead to cancer at various sites in the gastro-intestinal tract. This is despite the statement by Gross (1974) that, because several laboratories in several countries had failed to induce cancer in experimental animals using fibres less than five μ m in length, the concept that mesotheliomas and gastro-intestinal cancers arise from the ingestion of asbestos dust cleared from the lungs, should be abandoned.

2.13 Cancer of the larynx

From the patterns already discussed, it might seem likely that asbestos dust could also cause laryngeal cancer. However, there seems to be little reliable evidence in the recent literature. Shettigara and Morgan (1975) carried out a case-control study on 43 patients in Toronto, eliciting occupational and smoking histories. Both asbestos

exposure and cigarette smoking were considered "potent factors", with the "strength of association" higher for asbestos. Type of fibre was not considered, and the comment on relative potency is unwarranted in the light of the very small numbers on which it was based. Although their findings are claimed to be similar to those of Still and McGill (1973) in a hospital series, experience in the Quebec chrysotile industry was rather different. Here, McDonald and Liddell (1978) found no trace of a relationship between laryngeal cancer mortality and dust exposure, but a clear and convincing relationship with cigarette smoking. Only a small excess of deaths from laryngeal cancer was observed in the large series of asbestos insulation workers previously mentioned with regard to mesothelioma. Selikoff and Hammond (1975) considered deaths from this cause in those 11,656, nearly two-thirds of the complete cohort of 17,800, for whom smoking histories were available; four deaths due to larynx cancer were observed in the years 1967 through 1972, compared with 1.87 expected on the basis of US mortality rates for white males. The numbers were too small for the ratio of observed to expected (2.14) to be considered more than suggestive; all the cases had been smokers, the ratio being higher for those with a history of pipe and cigar smoking than for those who had smoked cigarettes.

2.14 Other health hazards

In their study of deaths to the end of 1975 in nearly 11,000 male Quebec asbestos workers, McDonald *et al.* (1979) used *inter alia* comparative composite cohort analysis (Case and Lea, 1955), sometimes called the man-years or the modified life-table method, to obtain numbers of deaths to be expected, for specific causes, on the basis of

rates for males in the Province of Quebec. The ratio of observed deaths to those expected can be seen to be a Standardized Mortality Ratio (SMR), adjusted for both age and era. The SMR for all causes was 1.1, and those for causes mentioned above were as follows:- Pneumoconiosis (asbestosis): 13.4; Lung cancer: 1.2; Cancer of oesophagus or stomach: 1.2; Cancer of colon or rectum: 0.7; Other abdominal cancers: 0.9; Laryngeal cancer: 1.0. The only unexpected finding is the low SMR for cancer of colon and rectum, despite the dose-response relationship mentioned above.

Other causes that produced SMRs noticeably above unity were Respiratory tuberculosis (1.3) and Accidents (1.2). The former has been eliminated as an effect of asbestos and appears to reflect the prevalence of the condition in the mining areas of Quebec, particularly Thetford Mines; the latter, although including work accidents, embraces all traumatic deaths and is clearly not a consequence of dust exposure. The SMRs for "Other" cancers, i.e. those not mentioned above, and for Cerebro-vascular diseases were both 1.1, but the usual test of statistical significance (Liddell, 1960) gave χ^2 values of only 0.8 and 0.7, respectively, despite the fairly large numbers involved (over 250 deaths from either cause). Thus, there would appear to be no additional health effect that could lead to premature death, at least in chrysotile mines and mills.

One minor effect is that asbestos corns may arise in those who get fibres into small open wounds (Harries, 1971). Finally, asbestos and asbestos products are mentioned several times in the index to the US Public Health Service's Guide to the Recognition of Occupational

Diseases (Gafafer, 1964), but in each instance not covered above it is a material with which the asbestos is mixed that is incriminated, e.g. benzene, cement or coal tar, not asbestos itself.

2.15 Summary; gaps in knowledge; thesis objective

It has been generally accepted for some years that inhalation of asbestos dust could lead to pulmonary fibrosis, carcinoma of the lung and the development of diffuse mesothelioma of the pleura and peritoneum (Bogovski *et al.*, 1973, p. xiii). There have also been several reports that asbestos exposure can lead to excess mortality from cancers of the gastro-intestinal tract and certain other sites, but the findings are not completely consistent.

There now seems little doubt that the different fibre types are associated with different risks. Risks of fibrosis, of lung cancer and of mesothelioma after exposure to crocidolite appear to be substantially higher than after corresponding exposure to chrysotile. The position of amosite may be intermediate, but too little information is available to place it accurately. There may also be differences in risk according to size of fibre, which may depend on the process.

The manifestations of pulmonary fibrosis include changes on the chest x-ray, respiratory symptoms, particularly breathlessness but sometimes also cough, increased sputum, or chest pain, impaired lung function, clubbing of the fingers, cyanosis and rales at the base of the chest (i.e. the adventitious dry crackling sounds described by Burton Wood, 1929). It is not clearly determined whether the fibrosis

is progressive after exposure has ceased.

The lapse period between the start of exposure and first signs or symptoms, some of which are also associated with cigarette smoking, is highly variable. The fibrosis, often called asbestosis but without consistent definition, can lead to premature death, which may not be coded, on death certification, to "pneumoconiosis" (codes 523-524 in the Seventh Revision of the International Classification of Diseases).

Lung cancers and mesotheliomas generally occur after long lapse periods. The former are also associated with cigarette smoking, and the risks appear to be multiplicative. The lapse period may be related to dose, age at first exposure, and amount smoked. An examination is in hand in the 245 lung cancer deaths within the 4,463 deaths up to the end of 1975 among the nearly 11,000 male Quebec chrysotile miners and millers being investigated by Professor McDonald and his colleagues; first results, in Table 2.2, provide no evidence of consistent variation in lapse period associated with dust exposure accumulated to age 45 or with smoking habit, but more detailed study is still required. The latent period between exposure to asbestos and appearance of mesothelioma is usually greater than 25 years, and even longer when the exposure was to chrysotile only (McDonald and Liddell, 1978).

The 1964 recommendations of the UICC Working Group (1965b) were for investigation of:- (1) fibre type; (2) dose-response relations; (3) effects of removal from further exposure; (4) all cases of mesothelioma; and (5) asbestos-exposed populations not so far studied. With regard to methods, the Working Group also recommended:- 1(a) col-

Table 2.2

LATENT PERIODS IN 245 DEATHS FROM CANCER OF THE CHEST

(Years from first asbestos exposure to death)

Smoking habit	Dust exposure accumulated to age 45 years (mpcf.y)					All
	<30	30, <100	100, <300	300, <1,000	1,000 or more	
Non-smoker	44.9 (5) *	42.8 (2)	40.5 (3)	33.8 (5)	45.9 (5)	41.5 (20)
"Undiff- erentiated"	38.6 (43)	35.9 (12)	35.0 (11)	41.2 (22)	43.2 (12)	39.0 (100)
15-25 cigarettes a day	35.7 (28)	38.0 (19)	40.8 (16)	39.5 (22)	40.8 (7)	38.4 (92)
26-50 cigarettes a day	36.4 (13)	40.6 (7)	38.2 (3)	39.6 (7)	44.9 (3)	38.9 (33)
All	37.7 (89)	38.1 (40)	38.6 (33)	39.7 (56)	43.2 (27)	39.0 (245)

* *Italic figures in brackets indicate number of deaths*

lection of full histories; 1(b) study of mortality and morbidity from *all* causes as well as from specific causes; and 1(c) consultation with statisticians at all stages from planning to analysis. 2 In all surveys:- (a) a standardized questionnaire should elicit symptoms (cough, sputum, dyspnoea and chest pain, as a minimum); and (b) when physical examination was possible, clubbing of the fingers, cyanosis and basal rales should be recorded. 3 A classification of chest radiographs should be developed. 4 Lung function tests should include FVC and Forced Expiratory Volume over 1 second ($FEV_{1.0}$).

By 1972, progress had been made on many of these recommendations. In a report to the Director of the IARC, the Advisory Committee on Asbestos Cancer could now make more specific epidemiological recommendations (Bogovski *et al.*, 1973, p. 341). A few of these were:- (i) the need for investigation, within type of fibre, of differences in size of fibre, and past exposure, in the risk of excess cancers of the lung and of other sites; (ii) investigation of possibilities and efficacy of early detection of disease; and (iii) study of differences between the effects of low continuous exposure and intermittent high exposure. Others concerned such matters as *post mortem* studies of mesotheliomas, secular trends in the general population, talc, pleural plaques, and cost-benefit analysis.

One other recommendation is of particular interest in the present context. It was "to interrelate radiographic appearances, lung pathology, respiratory function, dust content and type, in asbestos workers".

Although the various symptoms and signs of asbestos-related disease are undoubtedly important, excess mortality is the outcome of prime epidemiological interest. In the Quebec studies, and elsewhere, radiographic appearances have been related to dust exposure; respiratory symptoms and lung function have been related to dust exposure and smoking habit; and x-ray changes have been related to function. There have been many studies of mortality in relation to exposure, but few have included quantitative assessment of both duration and dust concentration; smoking is an important concomitant variable.

However, the outcome of greatest interest has also to be related to the symptoms and signs, and to exposure and smoking. A limited study of mortality in relation to x-ray change was reported in McDonald *et al.* (1974), but the interrelationships of all these variables do not appear to have been studied, although of great potential importance. Investigation of these relationships in Quebec chrysotile miners and millers forms the general objective of this thesis; specific objectives are given in Chapter 7.

Chapter 3

RADIOLOGICAL CLASSIFICATION

3.1 Introduction

In describing the development of the classification of chest radiographs of the pneumoconioses sponsored by the International Labour Office (ILO) in 1958, Van Mechelen and McLaughlin (1962) stated that "The abnormal x-ray shadows seen in the pneumoconioses constitute various combinations of linear, reticular, nodular and massive shadows, and none of them is specific in the sense that similar shadows may not be found in other non-industrial pulmonary conditions". The first classifications appear to have been those drawn up in South Africa and America, in 1916 and 1917, respectively. The ILO have sponsored five, i.e. in 1930 at Johannesburg, in 1950 at Sydney, in 1958 at Geneva, in 1968 at Geneva again, and finally the ILO U/C (1971) classification (Gardner *et al.*, 1930; ILO, 1953; 1959; 1970; 1972).

3.2 International classifications up to 1958

The first international classification was adopted in Johannesburg in 1930. Its concern was, for all practical purposes, with silicosis only and it was based as firmly on clinical symptoms as on radiological abnormality; three stages of disease were recognized. Although there was a meeting sponsored by the ILO in 1939, no new classification was adopted. However, note was taken of an American classifica-

tion which included radiological changes, histological appearances, clinical findings, both objective and subjective, and degree of incapacity for work.

Meanwhile Irvine, in South Africa, had in 1934 produced what appears to have been the first attempt to classify in purely radiological terms. Ten years later, Eck and Hanaut put forward a strictly radiographic classification, which has clear reference to silicosis; four stages of abnormality were distinguished - linear, micronodular, nodular and pseudo-tumoral - with three grades in each. In 1948, Van Mechelen and Belayew used this as the basis of what was called the Hasselt classification.

An important change in development came in 1949, when the Medical Research Council's Pneumoconiosis Research Unit (PRU) published a classification of coalworkers' pneumoconiosis (Fletcher *et al.*, 1949). This distinguished simple and complicated pneumoconiosis, and introduced four quantitative grades of either. In Sydney in 1950, the ILO followed PRU closely, although the number of grades of simple pneumoconiosis was reduced to three (ILO, 1953). Also, a category was added for discrete opacities not falling into the quantitative grades. Quite soon, this was found unsatisfactory for most purposes, and at a meeting of British and French experts in 1951 a compromise between Eck and Hanaut (1944), PRU (Fletcher *et al.*, 1949) and ILO, Sydney, 1950, was introduced; this was called the Cardiff-Douai classification (Cochrane, *et al.*, 1951). It allowed for small opacities in simple pneumoconiosis to be categorized by both their size (p, m, n) and their number (grades 1, 2, 3).

In 1958, Van Mechelen and McLaughlin (as they reported in 1962) had been asked to find out how far the Sydney classification was being used, and discovered that it was employed in only two countries, and that for specific purposes. The Cardiff-Douai classification was used throughout Europe in coalworkers' pneumoconiosis, but for no other occupation. They found, nevertheless, a clear desire for an international agreement, and the ILO called experts together in Geneva. The conference decided on limitation to "persistent radiological opacities in the lung fields provoked by the inhalation of mineral dusts". Van Mechelen and McLaughlin commented that these opacities constituted the majority of pneumoconioses, but that asbestosis (and berylliosis) "are said to present features different from other pneumoconioses". The ILO, Geneva, 1958, classification (ILO, 1959) retained most of the Sydney and Cardiff-Douai features. Suspect pneumoconiosis was to be recorded as "Z", which related to "increased lung markings", small opacities had sizes p, m, n defined, with three grades of profusion, while the grading of large opacities (or complicated pneumoconiosis) was reduced to A, B, C. An interesting development was the introduction, or better re-introduction, of a class, "L", for linear opacities, i.e. "numerous linear or reticular opacities, the lung pattern being normal, accentuated or obscured". Meanwhile Van Mechelen and McLaughlin made the important point that "the number of small rounded opacities is relatively difficult to establish, because there is always a desire to combine two different aspects, i.e. their distribution in the pulmonary fields and their profusion".

This classification did allow for the optional recording of "the main complications of the pneumoconioses" by what were called "addi-

tional symbols"; these were as follows:-

- (co) Abnormalities of the cardiac outline. To be replaced by
(cp): cor pulmonale, if this condition is strongly
suspected.
- (cv) Cavity.
- (di) Significant distortion of the intra-thoracic organs.
- (em) Marked emphysema.
- (hi) Marked abnormalities of the hilar shadows.
- (pl) significant pleural abnormalities.
- (px) pneumothorax.
- (tb) opacities suggestive of active tuberculosis.

3.3 Classifications of asbestosis

As seen in the preceding section, asbestosis had been ignored in all the international classifications before 1958, and even in that could only be recorded in terms of "L" or certain "symbols". The remark that this condition was "said" to present radiological shadows differing from those in the other pneumoconioses appears rather naive in the light of Merewether's description, in 1930, of changes (Harries, 1971, p. 12) occurring in four stages:

- I. increased linear striations
- II. fairly definite fine dusty stippling
- III. coarser mottling with increased linear striations
- IV. grosser lesions with pleural changes and displacements due
to the pull of fibrosing lesions.

In an important review, Bohlig (1965) pointed out that asbestosis did not present the same characteristics and uniform features as silicosis, and that several attempts had been made, from 1932 through 1956, to develop a classification, but always without international recognition. A three-stage scheme, originated by Saupe in 1938, had

been widely used but had the major drawback that the stages overlapped. Bohlig reported that he had tried to use the ILO classifications in asbestosis, and expressed the strong view that what was needed was development rather than a special, unrelated, scheme. The main difficulty lay in that most asbestoses (at least in Europe) showed linear marking and there was need to differentiate as to extent and density. He therefore proposed that the one class "L" be replaced by three grades of profusion (as for p, m, or n shadows), differentiated by the code "f" (for filamentum or fibra).

Sluis-Cremer and Theron (1965), at the same conference, pointed out the deficiencies of the ILO, Geneva, 1958, classification for use in asbestos workers, and also suggested three grades of profusion. They felt, however, that the linear markings could be classified as "fine" or "coarse" according as they were less or greater than 1 mm in width, and suggested the codes "Lf" and "Lc", respectively. These workers also proposed that pleural plaques should be recorded, and perhaps also pleural thickening, distinguishing whether diaphragm, mediastinum, walls or fissures were involved. They considered, too, that "symbols" should be added for bronchial carcinoma (Ca), mesothelioma (Me) and cystic changes (Cy).

3.4 The UICC/Cincinnati (or U/C) classification

These two proposals were modified into a system that was evaluated by a working group set up by the UICC (Union Internationale Contre le Cancer) Committee on Asbestos and Cancer in 1965. Meanwhile Professor Corbett McDonald and his colleagues working from McGill University had urgent need of a means of classifying several thousand

films from Quebec and had prepared proposals, and the US Public Health Service had expressed interest. The three groups met for four days in Cincinnati at the end of 1967, reviewed the results of the trials that each group had carried out, and eventually came to unanimous agreement on a new scheme designated as the UICC/Cincinnati (or U/C) classification. Its aims and principles were (Bohlig *et al.*, 1970):-

Aim 1. To provide a scheme for the systematic recording of the various radiographic appearances associated with exposure to asbestos and other dusts.

Aim 2. To provide a system in which the qualitatively different features of the film can be recorded separately and graded.

Aim 3. To provide a code that permits a brief description of the important radiographic features of the pneumoconioses.

Principle 1. As far as possible it is purely descriptive of radiographic appearances and does not use interpretive words such as "fibrosis" or "infection" which already have definitions in pathology.

Principle 2. It describes the natural history of the changes produced by asbestos and other dusts as far as is known, but it avoids the use of terms such as "early stages", "progressive" or "final".

Principle 3. It provides a system of recording semiquantitatively (with the help of verbal descriptions and standard films) features of the film which can be separately assessed with a reasonable degree of certainty.

Principle 4. It provides a means of describing the appearances seen in workers known to have been exposed to asbestos dust as well as to other dusts.

The U/C classification was an extension in several dimensions of the ILO, Geneva, 1958, scheme, and seems to have achieved most of its

intentions; however, Principle 1 (see above) was unfortunately not followed in its entirety. There is still a need to decide whether any radiographic changes are due to pneumoconiosis or not, and hence an element of diagnosis has been retained even in the latest developments; see page 6 of the present ILO U/C (1971) classification (ILO, 1972).

In the U/C classification, small opacities were subdivided into rounded and irregular; for rounded opacities, the "types" (or sizes) p, m, n, were replaced by p, q, r to reduce errors of transcription but without change of definition; for irregular opacities (replacing "L"), three "types" (or widths) s, t, u were introduced; each lung was divided into three zones, and a record was to be made of those in which the opacities appeared. Large opacities were subdivided into well-defined and ill-defined.

Perhaps the most important change was in what were called "other features". The "symbol" (p1) was replaced by (1) a record of whether either costophrenic angle was obliterated; (2) the grading of pleural thickening (or diffuse, uncalcified, plaques); and (3) the recognition of pleural calcification by site (diaphragm, walls or other), and by extent. In addition, when a diaphragm was ill-defined, this was to be indicated, as was the extent to which cardiac outline was ill-defined.

The number of "symbols", even excluding (p1), was increased to 18, of which six were obligatory, the rest optional.

Another major innovation was of the 12-point scale of profusion, developed within the National Coal Board by the present author and his

colleagues (Liddell, 1963; Liddell and May, 1966; Liddell and Lindars, 1969).

It had been agreed that, before the U/C classification was published, it should be subjected to tests of practicability and observer variation, both intra- and inter-observer. These tests, described briefly by Rossiter (1972a), were considered to show that the proposed scheme had reached a stage where it was likely to be a useful tool for epidemiological studies and it was therefore published (Bohlig *et al.*, 1970). It is fully described in the Appendix to this thesis, bound at the end of Volume 1.

3.5 The ILO U/C (1971) classification

Shortly after the decision to publish the U/C classification, the ILO adopted it as the "extended" ILO, 1968, classification (ILO, 1970); this was expected to be particularly useful for epidemiological studies in which the radiographic features were to be related to other measurements, such as indices of dust exposure or lung function changes (Jacobson and Lainhart, 1972). At the same time, a "short" classification was authorised for clinical use and for purposes, such as compensation, to which the earlier (1950 and 1958) international classifications had been put. This 1968 short classification was very similar to that of the ILO in 1958, except that pleural thickening of the chest wall and diaphragm was to be recorded by means of the "symbol" (p1) and pleural calcification by (plc). Five further "symbols" were made obligatory, with twelve "optional extras".

The US Public Health Service and others, particularly the

group working from McGill University, conducted several studies using the U/C classification in asbestos workers, beryllium workers, coal-miners, dockyard workers, etc. Much varied experience was gained in a short time, and a meeting to exchange information was held at the MRC's Pneumoconiosis Unit at Penarth, in April 1971. Several changes were adopted, and the recommendation made that the ILO and U/C classifications should be identical. At the Fourth ILO International Pneumoconiosis Conference, at Bucharest in September 1971, these proposals were approved, and the classification became known as the "ILO U/C (1971) international classification of radiographs of the pneumoconioses" (ILO, 1972; Jacobson and Lainhart, 1972). (The Penarth meeting had not resolved all difficulties in the use of the U/C classification, as discussed by Jacobson and Gilson, 1972.)

As three years previously, there were two versions, this time called "complete" and "short". In the complete classification, the lung zones were defined more exactly than before, and there was a strong recommendation that the combined profusion of both rounded and irregular small opacities should be recorded - but without any guidance as to how this should be done. In the U/C, 1968, classification, the extent of pleural thickening had been coded on a four-point scale; in 1971, both width and extent were to be coded, each on to a three-point scale. The number of "symbols" was increased to twenty, and their use was made obligatory.

The short classification of 1971 made allowance for the recording of small irregular opacities, distinguishing type (width), s, t, u, but retaining the older four-point scales (0, 1, 2, 3) for profusion

of both forms of small opacity, and for "combined" profusion, again strongly recommended. Pleural thickening was to be recorded as in the 1968 short classification, but "symbols" were to be treated as in the complete 1971 classification.

In 1975, I carried out a trial, on behalf of the Royal Commission on the Health and Safety of Workers in Mines (Ontario), to evaluate the x-ray classification still in use at that time in Ontario; it had been based on the one adopted nearly forty years previously by the South African Miners' Phthisis Medical Bureau for use in cases of silicosis. Three experienced readers assessed 269 films, most of claimants for workmen's compensation but including a fair proportion of unexposed men. The report (Liddell, 1975a) recommended the adoption in Ontario of the latest international classification, not only for the obvious reasons, but also because a substantial proportion of films in the trial revealed irregular small opacities which could not be recorded in the Ontario scheme.

A further benefit of the trial was that it allowed a study of the use of the ILO U/C (1971) classification for films of men with varied exposures. Some of the difficulties in the recording of small opacities were discussed in a recent report (Liddell, 1977). The most serious were in the averaging of profusion over the affected zones of the lung, and, as expected, in the recording of combined profusion.

Jacobson and Lainhart (1972) emphasised that periodic reappraisal and further changes might be required, but that eventually a classification might be developed encompassing all diseases of the chest. In

the last few years, a group of experts in the USA, working under the auspices of the American Thoracic Society, has been examining ways of using or adapting the ILO U/C (1971) classification for radiographs of persons not occupationally exposed to mineral dusts. The American College of Radiology, in co-operation with the National Institute of Occupational Safety and Health and the ILO, is to hold a symposium in Washington in September 1978, to make a further appraisal of the present classification, and the ILO is calling experts to a meeting in Caracas to be held the following month.

3.6 Standard radiographs

As Van Mechelen and McLaughlin (1962) wrote, "it is generally accepted that it is practically impossible to use a radiographic classification accurately without a set of standard reference films". They discussed problems of finding a single set of films representing the various pneumoconioses, and then of making copies for use as reference. However, the final set was complete by May 1961, when these authors submitted their report.

These same standard films for small rounded opacities and for well-defined large opacities were also used in the U/C classification, but new films had to be provided as standards of small irregular opacities, of obliterated costophrenic angle, pleural thickening of the chest wall, irregular diaphragm and irregular cardiac border.

A reference set of films for use with the ILO U/C (1971) classification had to be considerably larger than ten years previously, in order to cover all the features, and Dr. J. C. Gilson in a paper

entitled "Choice of Standard Films, with particular reference to those for small rounded opacities", privately circulated in 1971, commented that, even for small rounded opacities, the factors to be taken into account on choosing standards had changed considerably from what they had been in 1958-61, but that there were strong grounds for maintaining the levels of standards of this radiographic feature. However, the methods of averaging profusion, when not evenly distributed over the lung fields, were changed in an important fashion in 1971; this is one of the problems referred to in Section 3.5 above, and can be seen to create further difficulties in the selection of standard films. Nevertheless, by the end of 1972, the ILO was announcing that standard films were available.

The set consists of 21 plates, approximately 350 mm square. Most are radiographs of both lungs in one person, but three show two or three portions of the lungs of different subjects. One full film is normal in all features, and each of the mid-category profusions 1/1, 2/2, 3/3 are illustrated for each type of small opacity (p, q, r; s, t, u). However, in none of the reference films for profusion 1/1 do the opacities affect all six lung zones, and the same is true for half the films for profusion 2/2 and even for the 3/3 of type u. Well-defined large opacities of each category (A, B, C) are shown, but only category B of ill-defined large opacities. Pleural thickening and diaphragmatic pleural plaques are illustrated on one plate (with parts of the radiographs from three persons), and all other features of the classification are seen in films chosen as reference for small opacities. About half the "symbols" are also illustrated in like manner. Rounded and irregular small opacities are stated to co-exist in one of

the films, but the details give no guidance on how the assessment of combined profusion was made (rounded: q, 1/1 with no zones marked as affected; irregular: t, 3/3 in all six zones; combined 3/3).

There is little difficulty in accepting Gilson's comment that levels of standards should not be changed unnecessarily, and the U/C, 1968, classification had of course made use of the existing standard films wherever possible. However, the principle on which the 12-point scales of profusion of small opacities were based ought to have been better served by the introduction of reference films on the borderlines between categories in the short classification. A reader might then have been able to decide, in direct comparison, whether a specific film showed less or more profusion than the standard, thus facilitating differentiation between, say, 1/2 and 2/1. It also seems likely that the "middling tendency" (Morgan *et al.*, 1974) - placing the majority of films in the middle of the short categories, i.e. at 1/1, 2/2 or 3/3, reducing the numbers placed close to but on one side or other of the category borderlines - observed in most studies of the use of the 12-point scales would be reduced, because there would not be a mid-category film against which to make direct reference.

3.7 Radiographic technique

No discussion of the classification of x-ray films of the pneumoconioses could be complete without at least a mention of radiographic technique. Despite many attempts at some degree of standardization, there is little agreement among experts on the criteria of film quality. Indeed, in one trial of the U/C, 1968, classification, it was reported by Rossiter (1972a) that agreement about technique was

worse than for any other radiographic feature: the complete range of assessments (from acceptable to very poor) was recorded by different observers on a quarter of the films in the trial. The effects of film quality on the actual readings are complex, as has previously been discussed by, for example, Liddell (1961). It seems likely that some, perhaps all, readers adjust their readings of films they consider of poor quality to what they believe would be seen in an acceptable film. Further complication arises because in recent years a new type of technique has been developed; this uses kilovoltages in the range 110 to 140 kV, with short exposure times, one thirtieth or one sixtieth of a second, whereas the earlier techniques had used 60 to 80 kV with longer exposures (0.05 to 0.08 s) in order to get adequate penetration. While good radiographs are possible from each method, with careful attention to detail (ILO, 1972), the films are not necessarily comparable, as has been appreciated recently in one particular study (Becklake *et al.*, 1978) where film pairs were assembled consisting of one film by each technique.

Further discussion of this subject is outside the scope of this thesis.

3.8 Summary

Although international classifications of radiographs of the pneumoconioses had been sponsored by the ILO since 1930, those up to and including that adopted in Geneva in 1958 had been concerned primarily with silicosis and coalworkers' pneumoconiosis. Even in 1930, Merewether had described the radiological appearances of asbestosis in rather different terms, and at the New York Academy of

Sciences conference in 1964 on the biological effects of asbestos strong dissatisfaction was expressed with the ILO classification for use in asbestos-exposed populations. The UICC Working Group agreed proposals in 1967, which with minor modifications were adopted by the ILO in 1968, and confirmed, after several more international meetings of experts in all the pneumoconioses, as the ILO U/C (1971) international classification of radiographs of the pneumoconioses (ILO, 1972).

One of the main driving forces behind the 1967 UICC Working Group meetings had been the need for a classification into which to assess many thousands of films of Quebec chrysotile miners and millers. The earliest agreed version of the U/C classification was adopted for that purpose (Rossiter *et al.*, 1972), and as these readings were used in the research reported here, full details of that classification are given in the Appendix to this thesis.

Chapter 4

QUEBEC CHRYSOTILE STUDIES I : POPULATIONS AND MEASURES OF EXPOSURE

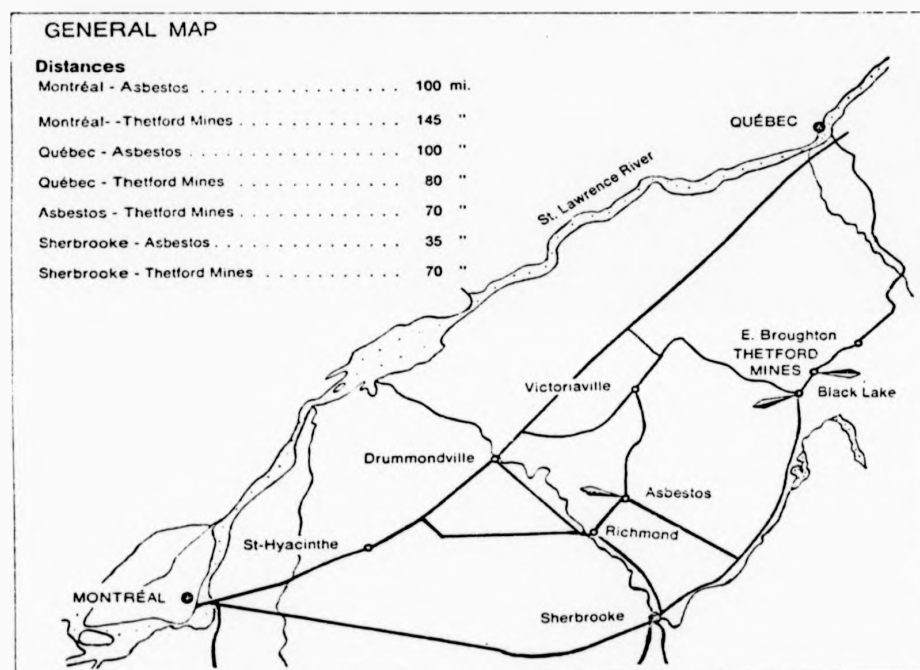
4.1 Introduction

Although Quebec's share of the world market of asbestos has been falling in recent years, annual production of chrysotile during the 1970s has been fairly steady around 1.3 million short tons, and the labour force has numbered about six thousand. Mining is carried out in two neighbouring areas of the region known as les cantons de l'est (the Eastern Townships) of Quebec; see the map in Figure 4.1. The first workings, opened in 1878, were at Thetford Mines and work still continues in that town and in the nearby Black Lake and East Broughton. In 1881, one man opened a mine at Asbestos; the company has continued since, also operating a small factory in the town for the manufacture of mixed asbestos products. After mining, the rock containing asbestos is processed in adjacent mills, which crush the rock, extracting the fibre and preparing it for commercial disposal.

Those who have worked in the mines and mills of Quebec are, as mentioned in Chapter 2, of particular interest for several reasons. First, their exposure has been purely to chrysotile. In most industrial applications, different fibres are used, mixed in the one pro-

Figure 4.1

MAP OF THE ASBESTOS-MINING REGION
OF SOUTH-EASTERN QUEBEC



cess, or separately but within the same factory. Thus, although chrysotile dominates greatly, it is difficult to find other populations who have been exposed to a single fibre. Even where such a population has been found, it has been quite small; cf. Elwood and Cochrane (1964) and Weiss (1977). The second reason for the importance of the Quebec workers is that there have been so many of them - nearly thirty thousand by the end of 1966. Thirdly, many of these persons (predominantly male) worked for a very short period only and so had minimal exposure; on the other hand, there were substantial numbers who had had many years of employment often in the extremely severe dust conditions of the past. Thus, there are possibilities for comparison between heavily and lightly exposed.

Following the 1964 recommendations of the UICC Working Group (1965b) on problems requiring epidemiological study, Professor J. C. McDonald and his team based on McGill University started their investigations of the health effects of asbestos in this population, in 1966, at the request of the Canadian government and with encouragement from the Quebec government. There have been many facets of the investigation, which is still continuing, and some sixty reports. This multidisciplinary approach to such a large population exposed to a single fibre, with estimates of the dust concentrations to which they were exposed, has led Enterline (1976) to write: "Except for McDonald's study of asbestos miners, however, no really 'grand' studies of asbestos exposed workers have ever been undertaken in which exposure and response are related".

The remaining sections of this chapter concern the setting up of

the project with its many sub-projects, and findings are outlined and discussed in the following chapter.

4.2 Principles

The principles of this investigation, although never so far stated explicitly, can be summarized as follows:- (a) to identify each person who had ever been employed by an asbestos mining company in the Eastern Townships; (b) to obtain certain basic information about each such person - sex, date of birth and history of employment in the industry; (c) to formulate precise questions for study; (d) to select the appropriate sub-population on which each question could best be answered; (e) to collect the necessary additional information about each defined sub-population; and (f) to analyse the full data with the best available methods.

Principles (a) and (b) were attacked by getting the personnel department of each mining company to compile a register of all persons currently or previously employed, as at 1 November 1966. A "buff card" was made out for each such employee. On the face, a record was made of his or her name, date of birth and address (at the time of employment), and on the reverse a detailed work history was provided; see below. There were 44 mining companies in this enumeration, but records for several, all but one very small, had been destroyed. This meant that no buff card could be made out for 500 or more persons, and that the history was incomplete for some others, mainly older men, who had worked in one of the mines concerned but been transferred to another when it closed. For a small proportion of persons, again mainly older men, dates of birth were incomplete and in a few instances

missing.

Because of the inevitable movement of labour between companies or from asbestos work to another occupation and back, there was need to bring together all the buff cards for each individual who had more than one. In many instances, there was agreement in every particular of name and date of birth on more than one buff card, and there could be considerable confidence that the cards referred to the same person. However, in some personnel departments, names had been recorded by a clerk unfamiliar with the mother tongue of the workers concerned, often an English-speaking clerk entering the names of French Canadians, or of immigrants from central Europe; further, age at the time of first entry on the books was often recorded, rather than date of birth. Inevitably, therefore, there were cases where the probability was that more than one card referred to one person, but confidence could not be complete. In every individual case, the evidence was reviewed on at least three occasions before a final decision was made; a small investigation of the quality of matching is reported in Chapter 7. At a comparatively early stage, McDonald *et al.* (1971) reported that they had registered 27,669 men and women, of whom 6,415 were in employment on 1 November 1966. Of the total, a little over 1,000 had been employed by more than one company.

The broad aims of the study are to relate dust exposure assessments for each worker, from the start of the industry, to mortality, radiographic appearances, pulmonary function and respiratory symptoms (McDonald *et al.*, 1974). Specific aims will be introduced in relation to the findings discussed in the following chapter. However, it seems appropriate to mention here the basic selection of chest radio-

graphs for use in several sub-projects.

At both Asbestos and Thetford Mines, chest x-rays are used for two main purposes, pre-employment medical examination and annual medical examination. The procedures started in 1936 at Asbestos, but at Thetford Mines were not introduced until 1946 and were not universal until several years later. The interval between medical examinations, and hence between successive radiographs, naturally varied somewhat depending on each individual's circumstances.

Following the same principles as for the identification of all employees, it was decided to select a radiograph for everyone who had had one. The most recent, before November 1966, was identified, and those of 15,689 persons in all were collected from the two medical clinics.

4.3 Work histories

The work histories, on the reverse of the buff cards, contained a list of every job the employee had ever had in the company, with date of start, and, from the next succeeding record, date of termination. Any time employment ceased, a record of the date was provided. Where there was more than one card for any person, they were brought together and the work histories were combined; in a very few instances, discrepancies appeared between histories given by different companies, and had to be resolved.

The reliability of these histories has to be considered. There are two aspects: are the dates of starting and ending employment

correct? and are all the jobs listed for each man? The former has been checked in a current study that will not otherwise be reported here. For over 1,200 men selected for this study, the work histories were "edited" by computer program, written to my specification, and a Work History Verification form was printed out. This form listed all identifying information and also the recorded date of first employment, and by which company, dates of leaving any company, dates of re-joining or of starting employment at another company, and date of last recorded employment. Field enquiries have been made to determine whether (a) those concerned worked in the industry before the first recorded date or after that last recorded; (b) any gap in recorded history was, in fact, spent, wholly or partly, in the industry; and (c) during any recorded spell of employment the man was in fact working elsewhere. Enquiries are not yet complete, but it is known that for about two thirds of the men the enquiries were "negative", i.e. have validated the recorded work history. For a considerable further proportion, the only "positive" response was about employment after 1 November 1966, i.e. without casting doubt on the validity of the record up to that point. Most of the remaining discrepancies were to be expected: light has been cast on some doubtful cases where buff cards had been assumed to refer to the same man; some spells of long-term absence from employment, particularly in the armed services during World War II, had not been recorded at Asbestos, because such men were kept on the books until their return; the records destroyed at one mine can now be at least partially filled; etc. In general, the enquiries have indicated that the buff cards were of high reliability in regard to dates of starting and ending employment.

No means of checking the second aspect (specific jobs) has been found. Their importance is for the calculation of exposure (see below) and the clear-cut dose-response relationships that have been determined in various sub-projects suggests that this aspect, *together with* assessments of dust concentrations (also see below), has been satisfactory.

4.4 Dust measurements

The jobs entered on the reverse of the buff cards were listed, within each company, or mine within company, and a total of 13,346 names distinguished. However, in many cases, several names were used for the same work and exposure, and the number of distinct jobs was reduced to 5,783. Dust concentrations were required for each job as they may have fluctuated throughout its existence. The following account relies heavily on two reports by Gibbs and Lachance (1972; 1974).

Since 1949, Maurice Lachance, Ingénieur, had made annual measurements of dust concentrations at working places in the dryers, crushers and mills in all companies. From 1946, various investigators had made similar measurements in the small factory at Asbestos. All Mr. Lachance's measurements were made with a midjet impinger, the others using a similar instrument and also several others. Records of concentrations were in millions of particles per cubic foot (mpcf). Well over 4,000 dust counts had been made by the end of 1966.

In mining and maintenance, and in certain other jobs, no dust assessments had been made by direct measurement, but dust levels were

estimated by investigating levels in the late 1960s and adjusting according to changes in operating procedures which had been reported by mining and maintenance personnel. Before 1949, few dust measurements had been recorded, and corresponding estimates were made, usually after interviews with employees of long service and in consultation with foremen, etc. In this way comparisons could be made with more recent conditions. All these estimates are necessarily approximate, but there was substantial agreement among those questioned. Nevertheless, for one reason or another, there is at least the possibility of some degree of overestimation (Gibbs and Lachance, 1972, p. 195).

The method of measurement used by Mr. Lachance was essentially that later approved by the Asbestos Textile Institute (1963). The count, sometimes referred to as "total dust" included both fibres and particles, and was carried out at a hundred-fold magnification. The dust counted was mostly below 7 μm in diameter (and so far from "total"); as fibre bundles exceeding 3 μm in width were rare, most of the dust counted was probably respirable.

Great variation was found between work places in dust levels, which were particularly high in certain areas of drying, milling, maintenance and waste disposal, and comparatively low in mining; differences were also found between mines, not only in different companies but also between those owned by the same organisation. Over the years 1949-66, when measurements had been taken, there was steady improvement in dust levels: the mean annual concentration in the mills fell from around 75 mpcf to about one-tenth that level. The mill at

Asbestos had the lowest concentrations throughout this period, reducing from about 30 mpcf in 1949 to a low level in 1956, which was fairly consistently maintained thereafter. In 1949-51, the mill with the worst experience each year had annual average concentrations above 200 mpcf, but in 1966, the average at the worst mill was below 15 mpcf.

Dust counts would probably have been substantially higher in the years before measurements were instituted. Thus they appear rather worse than in other historical studies (Knox *et al.*, 1968; Enterline *et al.*, 1972b) reported in Chapter 2.

Conversion to fibre counts would be desirable but has proved of doubtful value. Side-by-side sampling, using the midget impinger and a membrane filter device, has shown a poor degree of correlation between the two counts and shed little light on a means of conversion. The Quebec government's Comité d'étude, set up under Judge René Beaudry to study the health of asbestos workers in the Province, analysed up-to-date data supplied by Dr. G. W. Gibbs, and suggested that the relation: $(\text{fibres/ml}) = 10.97(\text{mpcf})^{0.68}$ would allow conversion (Dagbert, 1976). However, there was enormous variation in the ratio of the two counts: low counts on one instrument were, of course, often associated with low or medium counts on the other, but also occasionally with high values. Some extremes, estimated by eye from the figure in Gibbs and Lachance (1974), are:-

Midget impinger count (mpcf)	33	23	13	2
Membrane filter count (fibres/ml)	5	58	135	98
Ratio	0.2	2.5	10.4	49.0

This hundred-fold variation in ratios is mirrored in the very wide 95 per cent confidence limits provided by Dagbert on his conversion formula, i.e. $55.7(\text{mpcf})^{0.68}$ and $0.58(\text{mpcf})^{0.68}$; their ratio is $(55.7)/(0.58) = 96.0$

Over a realistic range of particle counts, i.e. at high levels, Dagbert's formula would suggest converting on the basis of five or so fibres/ml to unit mpcf, but Gibbs and DuToit (1978) stated that Dagbert had not adequately edited the data provided by Dr. Gibbs, and that the factor to convert historical particle counts should lie between one and five fibres/ml to unit mpcf. Converting on the basis of three fibres/ml to unit mpcf, the 1949 annual average concentration in the mills of Quebec, measured as 75 mpcf, may have been roughly equivalent to about 225 fibres/ml. Clearly, no great reliance can be placed on this figure, but there can be little doubt that dust levels were very much higher, by two orders of magnitude, than any modern "Threshold Limit Value" such as 5 or 2 or particularly 0.5 fibres/ml. Even in 1966, when the annual average concentration had fallen to around 7 mpcf, the fibre "equivalent" would appear to have been of the order of 20 fibres/ml, still unconscionably higher than today's standards.

4.5 Exposure calculations

When the National Coal Board's Pneumoconiosis Field Research (PFR) was set up in 1952 (Fay and Rae, 1959), a major concern was the calculation of indices of exposure to coalmine dust of each of the 35,000 miners under study. In the event, no attempt was made to assess historical exposures by more than a statement of the years worked at the coalface, elsewhere underground and on the surface, either at the

colliery where the man was questioned during a radiological survey or at any other mine. However, for the periods between surveys, detailed records were maintained of each man's work, job by job, day by day, taking account of overtime - which might be worked in another job - and absence. Dust measurements were made for each job and, thereafter, the length of time spent in each job was multiplied by the dust concentration there in the relevant period, and the cross-products were summed to obtain a single measure of exposure over the inter-survey period (usually about five years). The method of maintaining current histories was virtually identical to that introduced earlier for another purpose by Liddell and Finch (1958).

The Quebec studies required indices assessed over much longer periods, dating back to 1878. The method of obtaining them was similar to that of PFR, just described, taking the work histories on the buff cards as base; dates had been entered in terms of month and year only. However, the lack of the daily detail that had consumed such an enormous data processing commitment in PFR was much more than compensated for in Quebec by the vitally important estimates of early exposure.

For each of the 5,783 jobs, defined as above, and for each year of operation, an average dust concentration was estimated from the available dust measurements and approximations. The concentration was recorded on a 13-point scale, corresponding to:- 0.5, 2, 7, 12, 17, 22, 27, 32, 37, 42, 47, 70, and 140 mpcf. *Accumulated dust exposure*, or dust index, was originally calculated, as mpcf x years (or mpcf.y), by an adaptation of the method described above. An example

will illustrate the process:- consider a man who started in the industry during February 1965 in job 1 (dust code 3 in that year), moved to job 2 in September (code 5 in 1965, code 4 in 1966) and left in February 1966; the calculations are as follows.

Job	Year	Duration	Fraction of year	Concent- ration *	Cross-product
1	1965	Feb-Sep	$7/12 = 0.58$	(3) 7	$7 \times 0.58 = 4.06$
2	1965	Sep-Dec	$3\frac{1}{2}/12 = 0.29$	(5) 17	$17 \times 0.29 = 4.93$
2	1966	Jan-Feb	$1\frac{1}{2}/12 = 0.13$	(4) 12	$12 \times 0.13 = 1.56$
Accumulated dust exposure					<u>=10.55</u>

* The figures are (code) and corresponding concentration (mpcf).

For more recent studies, many of the exposure indices have been recalculated on an annual basis, and the proportion of each year worked has been recorded, a double-field being included on the computer record separately for each of the 63 years from 1904 (when the first employment of any of those involved in these particular studies started) through 1966. In the example above, the first 61 fields would be blank, and the entries for 1965 and 1966 would be:- 8.99 and 0.87; 1.56 and 0.13; respectively.

Several other indices of exposure were included in early studies. They were: accumulated dust exposure weighted for physical effort; accumulated dust exposure weighted for physical application; time-weighted dust exposure. This last is highly correlated with the first described (accumulated dust exposure, unweighted), and so little additional information can be gained from it. The others must be expected to have even higher correlations with the first, and have not in the event been found useful.

A fifth indication of exposure, useful because it does not take dust concentration into account, and so allows some form of comparison with other studies, is *years of exposure*. This can be expressed on a gross basis, counting from first employment to final departure from the industry, or on a net basis, omitting gaps in service from the index. These two measures have recently been termed gross and net service, respectively.

A correction to the accumulated dust exposure took account of variations in the length of the working week, which was generally 66 hours before World War II, but has been 40 hours in recent years. If the accumulated dust exposure is divided by length of service, the quotient will be only a rough indicator of average concentration, if the periods over which the averaging is done embrace changes in the length of the working week. To find true average concentrations, it would be necessary to re-calculate service, adjusting in such a way that the unit becomes a working year based on 40 hours a week, before finding the quotient. This would, however, mean that the working year could be as "long" as $66/40 = 1.65$ years on the present basis.

Despite the shortcomings discussed above, the estimated exposures are of very great value. While it may be impossible to place each individual subject precisely on a continuum of dust exposure, the great width of the continuum means that it is possible to distinguish workers who have had varying degrees of exposure. For example, a ten-point scale of dust exposure accumulated by age 45 has been found useful in the most recent study of mortality (McDonald *et al.*, 1979); the boundaries between the classes were drawn at 1, 3, 10, 30, 60,

100, 200, 300 and 600 mpcf.y, and of 10,939 men so grouped the class size was never less than 573, nor more than 1,607. While one cannot be completely confident that every individual has been placed into the correct class, employees with short service (less than one year, say) were most unlikely to be correctly in any but the lowest classes of dust exposure, while those with long service (twenty years or more, say) could not be at the lower end of the scale of exposure. This is illustrated by the two-way distributions in Tables 9.2 and 9.13, below. Indeed, because the accumulated exposure for a man with long service, probably having had many jobs, is a sum of more-or-less independent terms, the coefficient of variation of his estimated exposure is certainly small, by virtue of the Central Limit Theorem, compared with the variation of exposures between subjects. There may remain certain biases, but they can have little effect on any internal comparisons; see the discussion by Fay and Ashford (1964) on corresponding problems in British coal mines.

4.6 The "main mortality cohort"

Because excess mortality is undoubtedly the most important health effect of asbestos exposure, the mortality study will be outlined first. It was based on employees thought likely to yield the most valuable information, i.e. those born in the years 1891 through 1920, who had been employed for one calendar month or more (McDonald *et al.*, 1971). Those born before 1891 would have been even more difficult to trace; those born after 1920 would, even by 1978, be less than 60 years old and would not have completed their working life-times, still not having reached an age of high mortality. The cohort defined in these ways is here called the "main mortality cohort".

A substantial proportion of this cohort had had less than a year's service, and many of these together with some others of longer service had not been exposed to appreciable quantities of dust. In their first report on mortality, McDonald *et al.* (1971) stated that the selected cohort comprised 11,788 persons who met the criteria.

Attempts were made, under the supervision of Professor Alison D. McDonald, to trace every person in the cohort, to establish whether he or she was alive or dead, and if dead to seek details of exact date and place of death, so that a copy of the death certificate could be obtained. The search for ex-employees was initiated in the mining towns, through relatives and friends, and was extended to parish registers, provincial death records, the Canadian Unemployment Insurance Commission (UIC) and eventually to many other areas and organisations. Many deaths were reported as having occurred in other provinces, in the United States, and overseas. Careful examination was made of the field information, and many additional enquiries were undertaken to ensure that the tracing was reliable. In particular, it was sometimes found necessary to alter an earlier decision, previously made in terms of information on the buff cards only, as to whether these cards referred to one or more persons. The quality of tracing is discussed briefly in Chapter 7.

Tracing was carried out to four points in time: 1 November 1966 (McDonald *et al.*, 1971); 31 December 1969 (McDonald *et al.*, 1973; 1974); 31 December 1973 (Liddell, McDonald and Thomas, 1977); and 31 December 1975 (McDonald *et al.*, 1979). The numbers reported were as follows:-

	Total cohort	Traced	Traced as per cent of total	Reported dead	Deaths as per cent of traced
1966	11,788	10,421 *	88.4	2,457	23.6
1969	11,572	10,120	87.5	3,270	33.7
1973	11,391	10,245	89.9	4,110	40.1
1975	11,379	10,257	90.1	4,547	44.3

* including 598 registered with the UIC between 1964 and 1 November 1966, and presumed alive.

The "loss" of 400 persons (3.5 per cent) from the originally defined cohort was for several reasons: buff cards thought to refer to different persons were in fact found to concern only one, in more instances than the reverse occurred; and stricter application of the criteria for selection revealed some originally included who should not have been. More stringent definitions for acceptability of tracing reduced the number reported as traced at end-1969 compared with three years earlier, but unceasing efforts have now improved the trace rate to over 90 per cent; see also below.

Cause of death, from the death certificate in the vast majority of cases, was coded according to the Seventh Revision of the International Classification of Diseases by a senior coder recently retired from the Department of Demography of Quebec. Some death certificates could not be obtained, because the death had occurred before registration was introduced in Quebec in 1926 or because it had taken place outside Quebec in regions where authorities would not provide copies. In some of these cases an acceptable cause of death was elicited from relatives.

A smoking history was sought from those alive and from relatives and friends of those who died after 1950. The information was coded in

four categories:- number of cigarettes smoked a day, age when started smoking, and if appropriate when quit smoking, and whether a pipe smoker or not. Unfortunately, the coding was found to have been carried out inexpertly, and care is needed in interpretation; see Liddell, McDonald and Thomas (1977, p. 477). In preliminary work for this last cited paper, I studied the records to the end of 1973, for males, and found that 84.2 per cent of losses, i.e. those not traced, were before 1936. Of 9,723 men known to be alive in that year, 5,797 were traced alive, 3,750 were known to have died, and only 176 were untraced (59.6 per cent, 38.6 per cent and 1.8 per cent, respectively). Of the 8,672 known to be alive in 1956, smoking questionnaires had been completed for 5,771 still alive in 1974, for 2,600 who died 1956 through 1973 and four who were alive in 1965 but were subsequently lost to view, i.e. for a total of 8,375 (or 96.6 per cent). Another way of expressing these findings is that for the 9,834 men traced to the end of 1973, smoking history was not known for 1,090, all but 26 of whom had died, mainly before 1950 so that smoking histories had not been sought.

4.7 The "physiology cross-section"

This name is given to an age-stratified sample of current male employees who were examined, in 1967 and 1968, using (a) a respiratory symptom (and smoking) questionnaire, (b) lung function measurements, and (c) the chest radiograph. The study was carried out primarily to determine the relationships between exposure to dust on the one hand and the various signs and symptoms that could be assessed by the tools listed above on the other hand. Because there were so few women in the industry, most of whom had been employed in low dust

concentrations, the study was confined to men; it was decided to include higher than representative proportions of older men.

From the register of persons ever employed in the industry up to 1 November 1966, it was determined that there were 6,415 current employees, of whom 6,180 were males. The 102 who were less than 21 at the time to which the register referred and the 37 who were 65 or more were excluded. A random sample was taken from each remaining five-year age group to yield a total of 1,027; the sampling fraction varied from 14 per cent in those of ages 21 through 25, to 47 per cent of those 61 through 65. The examinations took place in the summer of 1967, but only 885 men were seen and tested: 85 had died or left and 57 refused to participate. These losses were mainly among older men, and in the following summer all 241 men still at work and aged 61 through 65 but not already examined were called; a further 185 sets of tests were carried out.

A total of 1,069 men were tested, and included in a study of lung function in relation to radiographic changes (Becklake *et al.*, 1970). However, a serious deficiency in the questionnaire or the records of the lung function tests, or in the work history, led to the exclusion of 54 men, so that studies of respiratory symptoms and lung function in relation to dust exposure were confined to 1,015 men (McDonald, Becklake *et al.*, 1972; Becklake *et al.*, 1972).

The British Medical Research Council Questionnaire on Respiratory Symptoms (1966) was used with slight modifications and after translation into French, so that each man could be interviewed in the lan-

guage of his choice. One fluently bilingual interviewer administered the questionnaire to all but 16 men (among the 54 excluded as noted above). Smoking history was recorded in the usual way during these interviews, and ages were verified; many required correction compared with the information on the buff cards.

In each of the two mining towns, a field laboratory was set up and the two technicians each tested eight men a day. Becklake *et al.* (1972) reported as follows: "The following tests of lung function were carried out in the order listed, using methods described fully elsewhere: (1) carboxyhemoglobin level measured by an oxygen re-breathing technique; (2) functional residual capacity (FRC) using a helium dilution technique; (3) vital capacity (VC) followed by three tests of forced vital capacity (FVC), the largest of which was also analyzed for the forced expiratory volume expired in 0.75 second ($FEV_{0.75}$) and in 1.0 second ($FEV_{1.0}$), for the $FEV_{1.0}/FVC$ ratio expressed as a percent, and for the maximal midexpiratory flow (MMF); (4) diffusing capacity for carbon monoxide at rest measured by the single breath method ($D_{CO}[SB]$) as the product of Krogh's diffusion constant (K) and alveolar volume ($TLC[SB]$) calculated from helium dilution by the single breath; and (5) diffusing capacity for CO ($D_{CO}[SS]$) and the CO extraction rate (%) measured by the steady-state method at rest and at two levels of exercise (200 and 400 kg.meters/min) on a bicycle ergometer. Minute ventilation (\dot{V}_1) and oxygen consumption (\dot{V}_{O_2}) were also measured at the same time."

4.8 Procedures for reading 15,689 radiographs

As previously mentioned, the most recent radiographs of 15,689

guage of his choice. One fluently bilingual interviewer administered the questionnaire to all but 16 men (among the 54 excluded as noted above). Smoking history was recorded in the usual way during these interviews, and ages were verified; many required correction compared with the information on the buff cards.

In each of the two mining towns, a field laboratory was set up and the two technicians each tested eight men a day. Becklake *et al.* (1972) reported as follows: "The following tests of lung function were carried out in the order listed, using methods described fully elsewhere: (1) carboxyhemoglobin level measured by an oxygen re-breathing technique; (2) functional residual capacity (FRC) using a helium dilution technique; (3) vital capacity (VC) followed by three tests of forced vital capacity (FVC), the largest of which was also analyzed for the forced expiratory volume expired in 0.75 second ($FEV_{0.75}$) and in 1.0 second ($FEV_{1.0}$), for the $FEV_{1.0}/FVC$ ratio expressed as a percent, and for the maximal midexpiratory flow (MMF); (4) diffusing capacity for carbon monoxide at rest measured by the single breath method ($D_{CO}[SB]$) as the product of Krogh's diffusion constant (K) and alveolar volume ($TLC[SB]$) calculated from helium dilution by the single breath; and (5) diffusing capacity for CO ($D_{CO}[SS]$) and the CO extraction rate (%) measured by the steady-state method at rest and at two levels of exercise (200 and 400 kg.meters/min) on a bicycle ergometer. Minute ventilation (\dot{V}_1) and oxygen consumption (\dot{V}_{O_2}) were also measured at the same time."

4.8 Procedures for reading 15,689 radiographs

As previously mentioned, the most recent radiographs of 15,689

persons had been collected (Rossiter *et al.*, 1972). They were to be used for several purposes, *viz*: (a) an examination of the U/C classification; (b) for relating to respiratory symptoms and lung function in the physiology cross-section; and (c) for relating to dust exposure measures. Six readers, all of whom had helped in the development of the U/C classification, participated in the reading which took place in three stages. First, a random sample of 600 films was read once each by all six readers, working independently, to allow an examination of inter-observer variation; so also were the films of the subjects in the physiology cross-section, to provide the most reliable basis for relating radiological findings to function measurements. All the films were then reassembled into thirty batches, by a quasi-random procedure of shuffling, and each reader read five batches. This second stage permitted some study of intra-observer variation, for each reader had now read a considerable number of films on two occasions. Finally, a complex procedure was adopted whereby all films which at the second stage had been recorded as in any way abnormal (by a single reader) were read by three others, and a sample of those assessed as normal at stage two were read by at least one other reader. The total number of assessments (excluding those on films considered unreadable) was 42,022; we have recently found that there were 1,868 sets of six readings, one per reader, from the first stage (a total of 11,208 assessments), 15,570 readings at the second stage (almost equal numbers by each reader, varying only between 2,553 and 2,611), and a further 15,244 at the third stage.

As a preliminary to the study of the relationships between radiographic findings and indices of dust exposure, the following films

were excluded: those of students employed in the summer only; those of applicants examined but not employed; those for men whose personnel records had been destroyed; a few for subjects with otherwise incomplete work histories; and a few films of very poor quality. This left 13,021 (or 83 per cent), of whom 12,174 were of males. Of these, 967 were listed as past or present employees of the small factory at Asbestos, leaving 11,207 production workers. In the report by Rossiter *et al.* (1972), relationships between radiological changes and indices of exposure were examined in the males aged 36 through 65 at the time of last recorded job in the industry (to November 1966); there were 6,129 production workers and 398 factory workers.

4.9 The "radiographic progression cohort"

In 1975, Eyssen reported on a study which had had the objectives: (1) to determine the most suitable method of assessing radiographic progression in the individual to allow the changes to be related to measures of his exposure; (2) to make a first examination of the relationship between radiographic progression and asbestos exposure; and (3) to describe changes over the years in the prevalence of radiographic change in the Quebec chrysotile producing industry. Eyssen stratified the 12,174 male subjects defined by Rossiter *et al.* (1972) - see previous section - by place of work (Asbestos or Thetford Mines), length of employment and whether they showed evidence on the latest film to 1966 of radiographic abnormality or not. Random samples were drawn from each stratum, with high sampling fractions for strata containing abnormal films and low fractions for strata with only normal films. In this way, 283 men were selected; for each man five radiographs were collected, including the latest available at that time,

i.e. up to 1971, and four previous films at roughly five year intervals spanning about 20 years.

Two methods of assessment were adopted by five readers, all of whom had been concerned in the main reading described in the last section. One method was side-by-side reading of the films in known temporal order, using the ILO U/C (1971) classification with further fourfold elaboration of the scales of (i) profusion of small opacities, both rounded and irregular; (ii) both width and extent of pleural thickening; and (iii) ill-defined cardiac outline. The other method was independent reading of all the films in randomized sequence into the (unmodified) complete ILO U/C (1971) classification (ILO, 1972).

This work was carried out before the mortality analysis to the end of 1973, and so the revised dust exposure calculations on an annual basis were not available even for those men in the present study who were in the "main mortality cohort". Calculations were carried out *ad hoc* of exposures in the quinquennia up to the earliest film for each man included in the study, and for the three periods between that film and the next three succeeding films included. Smoking histories were available for the men also in the "main mortality cohort" but not for the others. The two medical clinics, at Asbestos and Thetford Mines, provided what information they could from the subjects' medical histories on the smoking habits of these men, and so it was possible to classify all but three subjects as smoker or not; the three with unknown history were treated as smokers as the more likely habit.

For a more detailed examination of radiographic changes in relation to dust exposure, and other factors (Liddell, Eyssen *et al.*, 1977), closer study of the work histories revealed discrepancies, or employment outside the Quebec asbestos industry in work that involved exposure to asbestos or other dusts, in twelve men; these and four for whom there were important gaps in the radiological findings were excluded from the analyses, which were based on the side-by-side readings of four readers only, because one had not completed assessments on all films.

4.10 Summary

In 1967, Professor McDonald's team registered all workers, nearly thirty thousand, who had been employed in the Quebec chrysotile producing industry some time since its inception, in 1878, and November 1966. For various studies, the following populations were defined:-

- (a) The "main mortality cohort" of those born in the years 1891 through 1920 who had been employed for one calendar month or more. Improving information over the years and stricter application of the criteria for inclusion in the cohort have reduced the numbers slightly from those first reported, and there are now 11,379 persons in the cohort, including 440 females (McDonald and Liddell, 1978).
- (b) The "physiology cross-section", a sample of males at work in November 1966, weighted heavily towards the older age groups. A total of 1,069 men were interviewed, but data from respiratory symptoms questionnaires and lung function tests were complete for only 1,015 (McDonald, Becklake *et al.*, 1972;

Becklake *et al.*, 1972).

(c) The "radiographic progression cohort", a sample of 283 men for whom five chest radiographs were available spanning an average of twenty years. Because of some doubts about work histories, including exposure to possible airborne health hazards outside the Quebec industry, the cohort was reduced to 267 for further analysis (Eyssen, 1975; Liddell, Eyssen *et al.*, 1977).

(d) All persons, totalling 15,689, who had had a routine chest radiograph at one of the medical clinics in the Eastern Townships before November 1966. Exclusion of students employed in the summer only, applicants for work not taken on, some for whom personnel records had been destroyed and a few whose films were of very poor quality reduced the effective study population group to 13,021. However, the latest film for all 15,689 was collected and assessed.

As the main aims of the investigation were to relate dust exposure assessments for each worker to mortality and other biological responses to asbestos exposure, calculations were made of accumulated dust exposures, through work histories and estimates of dust concentrations, for all persons included in the various facets of the enquiries (Gibbs and Lachance, 1972; Liddell, McDonald and Thomas, 1977). Other indices of exposure were also obtained for certain specific purposes.

Chapter 5

QUEBEC CHRYSOTILE STUDIES II: FINDINGS

5.1 Introduction

In this chapter, I review the main findings from the studies by Professor J. C. McDonald and his colleagues of the health effects of asbestos exposure in the miners and millers of Quebec chrysotile. Sections 5.2 and 5.3 deal with radiological changes, respiratory symptoms and lung function, each in relation to asbestos dust exposure, and the next section with the interrelationships of signs and symptoms. Sections 5.5 and 5.6 concern mortality in relation first to dust exposure and then to radiographic changes. A brief summary follows, and in Chapter 6, the findings from other studies, both in chrysotile and in relation to other fibres, are discussed.

5.2 Radiological changes in relation to dust exposure

Of the two earliest reports relating radiographic appearances to exposure to asbestos dust (Rossiter *et al.*, 1971; 1972), the first was of a preliminary nature, concerning only 809 employees of one company at Thetford Mines. The authors' own summary (Rossiter *et al.*, 1971, p. 206) states that: "Small rounded opacities were related to total dust, but not to the other two indices, and ill-defined cardiac outline to total dust weighted by physical effort. Pleural thickening

and pleural calcification were related to age, but not to any dust index ... The distribution of pleural plaques in the Quebec asbestos mining areas was not uniform, the greatest concentration being in those who have worked in or near this mine." Their conclusion that their findings justified the use of the U/C classification could be accepted, but the results themselves needed generalization.

The main study (Rossiter *et al.*, 1972; also summarized by McDonald *et al.*, 1974) provided that generalization. The main concern was with all male production workers aged 36 through 65 who had ever had a chest radiograph; they numbered over six thousand. A further 398 male factory workers in the same age range were also considered. In each case, the radiographs examined were the latest available to 1966, and the workers' ages used in these reports were at 1 November 1966 for current employees, and at the end of employment for ex-employees. As radiographs were supposed to be taken annually, it might be expected that the age at x-ray was on average six months less than the reported age; it seems likely, however, that the average interval between x-rays was greater than a year, because of missed appointments and similar reasons, and the age at x-ray may have been on average rather more than six months younger than reported. However, the bias thus introduced into an individual's age is likely to balance out in the cross-sectional study reported here.

The men were classified by mining area, Asbestos or Thetford Mines, by five-year age-groups and separately by the five dust exposure indices outlined in section 4.5 above.

The procedures for reading the radiographs have also been described above; see section 4.8. Although it would have been simplest to derive an assessment for each film by averaging the category for each feature for the readers involved, up to six, it was thought that more information would be obtained by taking account of the distributions of categories for the individual readers in the random series of 600 films all had assessed, and that this would allow for inter-observer variability. To this end, radiological indices were calculated on scales whereon, for each factor, the change from the lower to the upper end of category (or grade) 1 was taken as the unit; these ends of the category were labelled 1 and 2 respectively. The distribution of categories for individual readers in the series of 600 films they had all read were used to "adjust" for differences between readers in their levels of reading. Thereafter, the scores were averaged for use directly in regression analyses; for prevalence statements however, the average scores were "discretized" and also often standardized for factors of less than immediate concern. Further, this scoring process was only possible for the graded features of the U/C classification; other features were taken as present if at least half the readers who had assessed a particular film thought so. Despite the unequal number of readers to a film, the authors considered that the reading pattern would have led to only small biases (Rossiter *et al.*, 1972); however, without full details of the adjustment procedure, it is not possible to examine its justification. At the worst, however, it could have affected only slightly the general patterns revealed in the analysis.

The main findings of this study illustrated in Figure 5.1 (taken from Rossiter *et al.*, 1972), can best be quoted from McDonald *et al.*

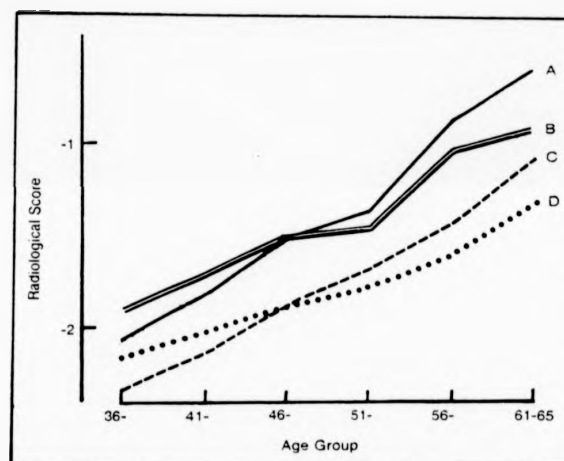
Figure 5.1

RADIOLOGICAL SCORES

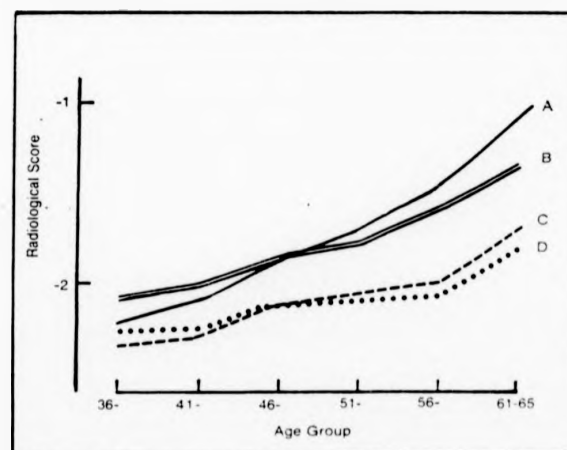
Variation in the average score from cohort to cohort,
with and without standardizing for exposure differences.

- A Thetford Mines
- B Thetford Mines, standardized for exposure
- C Asbestos
- D Asbestos, standardized for exposure

Irregular
small opacities



Pleural thickening



(1974), *viz*: "The two main roentgenographic indices of response to asbestos exposure are irregular small opacities and pleural thickening. The prevalence of these, and of all other roentgenographic changes, were higher in the Thetford Mines area than in the Asbestos area of Quebec, although the two areas are only 80 km apart and the asbestos mined is geologically similar. The association of the changes with dust exposure was also stronger at Thetford Mines than at Asbestos. ... At Thetford Mines the prevalence of irregular small opacities of category 1 or more rose steadily with increasing dust exposure, whereas for category 2 or more the relation to dust exposure was less marked, except for the considerable rise in the most exposed workers. Even with allowance for differences in dust exposure, the prevalence of category 1 or more was markedly age-related, rising to 14.8% for those 61 to 65 years old. This age effect was much lower for category 2 or more, and amounted to only about one third of the change associated with dust exposure. At Asbestos, the prevalence of irregular small opacities of category 1 or more rose to 9.2% for those aged 61 to 65, and there was virtually no relation to dust exposure. With respect to only category 2 or more, the relation to age was much lower and prevalence increased among those with the highest dust exposure. For pleural thickening, the effect of age was slightly greater than the effect of exposure on the prevalence of grade 1 or more, and of grade 2 or more, for both mining areas.

"The biggest difference among all the roentgenographic features was in pleural calcification, for which the prevalence of grade 1 or more was 0.4% at Asbestos and 5.2% at Thetford Mines. In spite of the relationship to dust exposure, no correlation exceeded 0.3. This

is largely a reflection of the very high proportion of men who showed no roentgenographic change. Some of the differences between the two areas were not surprising, as overall dust exposure levels at Asbestos were considerably lower than at Thetford Mines, but others cannot be explained in terms of dust exposure or geology. If variation in fibre content of dust were an important factor, the results in mine workers, for whom the fibre proportion would be low, should differ from those for mill workers, in whom the fibre proportion would be higher. Altogether, there were 506 persons who had worked for ten or more years entirely in mining or entirely in milling. Analysis of roentgenographic changes in these men showed that mill workers had slightly higher prevalence of irregular small opacities, but the differences between Asbestos and Thetford Mines remained. No other consistent differences could be detected between the mine and mill workers.

Two further reports on radiological changes in relation to dust exposure were based on the "radiological progression cohort"; see section 4.9. The first of these (Eyssen, 1975) was concerned mainly with a choice between methods of assessing radiographic change in serial films. Correlations between measures of exposure and of radiographic progression had the first objective of determining whether either side-by-side reading of all five films in known temporal sequence into fine scales of profusion produced consistently higher correlations than independent randomized reading into the ILO U/C (1971) classification, without amendment; only a secondary objective was to elucidate any readily available epidemiological findings (Eyssen, 1975, p. 102). In the event, the correlations between radiographic progression, however assessed, and levels of dust exposure whether before the first

film or in the intervals between films were not substantial.

The other study (Liddell, Eyssen *et al.*, 1977) of the radiological progression cohort related to 267 men, excluding several from the complete cohort who had had exposure in the intervals between films or whose work histories were in considerable doubt. The analysis took place in three phases. Phase 1 was a "cross-sectional" study of all 267 men, to relate the x-ray status of the earliest selected film to potential stimuli. The men were then classified into two cohorts. The first cohort consisted of 150 men whose earliest film in the study contained no evidence of abnormality according to all four readers using both side-by-side and independent reading; Phase 2 was a study of "attacks" in this cohort. The remaining men formed the second cohort, and Phase 3 was a study of the progression of radiographic changes in these men from their first film which could be treated as "less-than-normal" over the rest of the period, averaging twenty years in total, covered by the available x-rays.

Phase 1 showed that abnormality in the earliest film was related mainly to the time since first employment, in close conformity with the findings earlier of Rossiter *et al.* (1972). Phase 2 revealed that, in 45 of the 150 men completely normal at first film, some radiological abnormality developed during the period of observation: incidence was weakly related to age; at Asbestos, the risk of developing small opacities was lower in smokers than in non-smokers. In Phase 3, there was an irregular pattern of correlation, more evident in Thetford Mines than in Asbestos, between radiological progression and various stimulus variables.

Liddell, Eyssen *et al.* (1977) concluded that associations between radiological responses and measures of asbestos exposure were, as always, weak, despite powerful methodology. They felt this indicated that effects were obscured by other factors (including susceptibility) uncorrelated with exposure. Several possibilities required consideration. First, the variables - response, stimulus or disturbing - chosen for analysis may not have been the most appropriate; or they may have been inaccurate. The x-ray shadows are only indirect signs of disease, and their assessment is seriously hampered by observer variation (despite attempts to minimise it by taking all four readings into account) and by the inevitable changes of radiographic technique over such a long period of study (again perhaps better allowed for in side-by-side reading than when films were read independently). The dust measurements were, of course, at best with imperfect instruments, sometimes only educated guesses, and not necessarily bearing much relationship to dust retention in the lung. Secondly, if asbestosis is progressive, radiographic change will be observed in men with long service, irrespective of recent exposure. Thirdly, there may well be differences in factors of social, psychological, behavioural, physiological or immunological nature that modify the amounts of dust inhaled, the proportion and constitution of what is retained, and the nature of the pathological response. In this study, 80 per cent of the men exposed for over 30 years, often to heavy concentrations, remained completely unaffected as far as their chest x-rays were concerned, whereas others were attacked after quite short periods of employment in the more recent eras when dust concentrations were comparatively low.

5.3 Respiratory symptoms and lung function in relation to dust exposure

As explained in the previous chapter, an age-stratified sample of 1,015 current male employees was examined, mainly in 1967, to explore the relationships between respiratory symptoms and lung function, on the one hand, and, on the other, dust exposure, taking age and smoking habit into account. There are two reports, which deal with symptoms (McDonald, Becklake *et al.*, 1972) and function tests (Becklake *et al.*, 1972) separately.

The symptoms studied were: winter cough; winter cough for three months of the year; phlegm in winter; phlegm in winter for three months of the year; cough and phlegm for three months of the year; wheezing most days; nasal catarrh for three months of the year; breathlessness compared with others of the same age; and disabling chest illness in the last three years. As far as possible, terms were used in the same way as others had used them, to allow comparison between studies. Smokers were classified in two ways, by current habits and in terms of cumulative numbers of cigarettes (or equivalent) smoked. The index of exposure to asbestos was the accumulated dust exposure.

The distributions of cough, phlegm and wheezing all followed a similar pattern: prevalence increased with age, and rates were much higher for smokers than for non-smokers or ex-smokers. However, they did not appear to be associated with dust exposure, except perhaps in men over 50. On the other hand, breathlessness, although increasing with age, was not clearly related to smoking but showed a definite, positive, association with dust exposure; this finding was not sensi-

tive to the degree of breathlessness being considered. Disabling chest illnesses were associated with age only, and nasal catarrh showed no important or consistent trends.

Attempts to disentangle the effects of the three factors (dust, smoking and age) were not entirely successful. However, the authors concluded that the prevalence of persistent cough and phlegm (bronchitis) was related to age and smoking habits and *perhaps* (my emphasis), in non-smokers and light smokers, also to dust exposure. Breathlessness on exercise was related to age and dust exposure but not to smoking. The age-corrected prevalences of breathlessness given by McDonald, Becklake *et al.* (1972, Table 4) have been further adjusted for smoking habit by the "equivalent average" method (Yule, 1934) in Table 5.1.

For the examination of lung function tests, the men were divided into only two groups according to their smoking habits, non-smokers being those who had never smoked even one cigarette a day for as long as a year. Thereafter, each group was divided into six classes according to accumulated dust exposure, and mean values of the various test measurements were calculated for each class, after "standardization" for age, height and weight, by means of a series of regression analyses. Many of the function measurements were associated with dust exposure; see Figure 5.2. The following paragraph is quoted from Becklake *et al.* (1972).

"Lung volumes. - In both non-smokers and smokers the standardized mean value for total lung capacity (TLC) fell with increasing dust ex-

Table 5.1

PREVALENCE OF BREATHLESSNESS
BY DUST EXPOSURE

1,015 men in the "physiology cross-section"

(Age-corrected prevalence percentages,
further adjusted for smoking habit)

Dust exposure accumulated to November 1966 (mpcf.y)	Prevalence of breathlessness (%)
Less than 10	5.0
10, less than 100	16.4
100, less than 200	23.8
200, less than 400	24.4
400, less than 800	28.8
800 or greater	38.0

Figure 5.2

LUNG FUNCTION, SMOKING AND DUST EXPOSURE

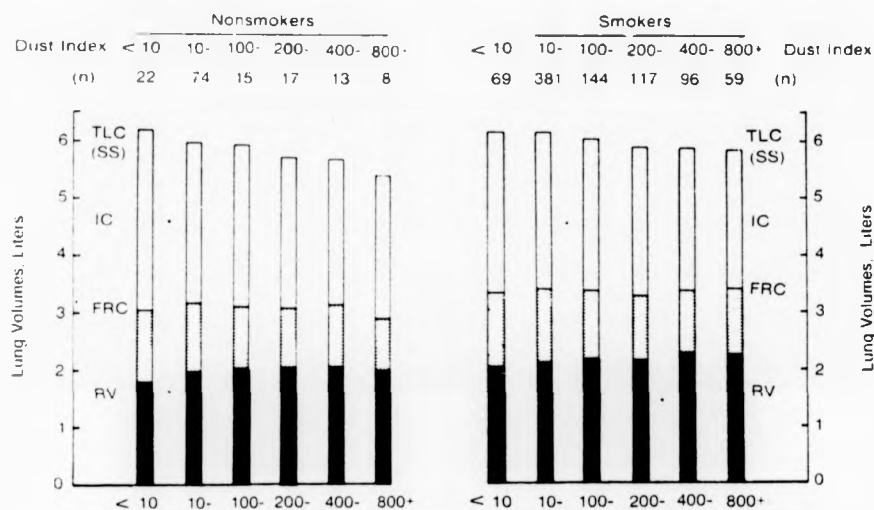


Fig 1.—Standardized mean values for subdivisions of lung volume (TLC(SS), IC, FRC, and RV) in nonsmokers and smokers divided by dust index. Number (n) of individuals in each subgroup is indicated.

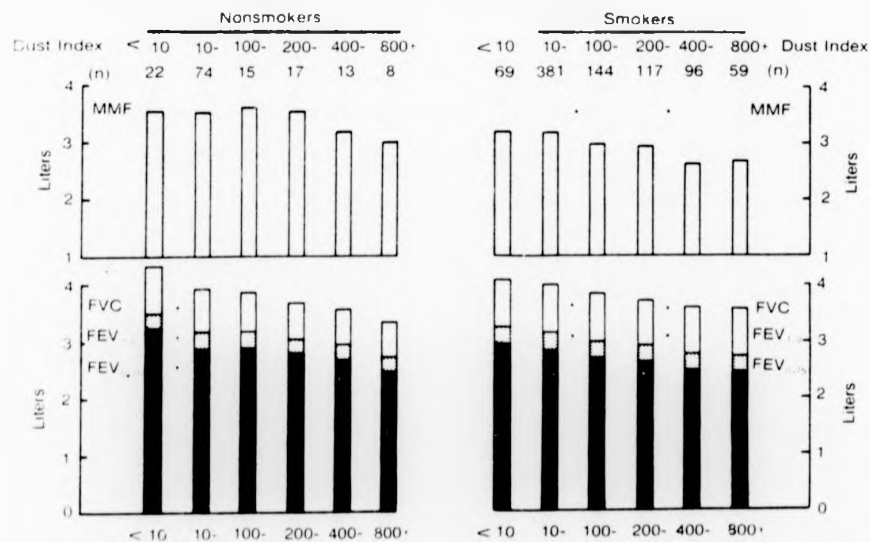


Fig 2.—Standardized mean values for flow rates (MMF, FEV_{1/5}, FEV_{1/2}, and FVC) in nonsmokers and smokers divided by dust index. Number (n) of individuals in each subgroup is indicated.

posure, due primarily to reduction in the inspiratory capacity ($IC = TLC - FRC$). Since IC is one of the components of VC , a fall in relation to increasing dust exposure was also seen in the FVC . In non-smokers the other subdivisions of lung volume, in particular FRC and residual volume (RV), did not show any evident trend with increasing dust exposure. In smokers, however, there was a progressive increase in RV . *Flow rates.* - Both in non-smokers and smokers, there was a progressive fall in FEV with time ... These decreases were probably attributable in part to diminished VC (or FVC) with increasing dust exposure. In contrast, MMF and $FEV_{1.0}/FVC$ were reduced only in the higher dust index groups in non-smokers. Results of both tests were lower on average in smokers than non-smokers but were only reduced substantially in men with high dust exposure. *Diffusing capacity.* - Neither of the standardized measurements of diffusing capacity at rest ... showed any consistent trend in relation to increasing dust exposure in non-smokers or smokers. There was a fall in diffusing capacity on exercise ... with increasing dust exposure in the non-smokers, though because of the small numbers in five of the six non-smoker dust-exposure subgroups, this conclusion is tentative. However, the highest standardized values for $D_{CO}(SS)$ both at 200 kg.meters/min and at 400 kg.meters/min were seen in the non-smokers with insignificant dust exposure [less than 10; and 10, but less than 100 mpcf.y]. Among the smokers, there was a fall in diffusing capacity on exercise ... but much less than that seen in non-smokers."

An important objective of the complete research programme was reported by Becklake *et al.* (1972) to be to determine methods of surveillance of workers exposed to asbestos but as yet unaffected accord-

ing to any clinical test. The authors gave their opinion that IC, FVC and FEV, which were sensitive to even low levels of exposure in non-smokers, and related to dust exposure over the full range in both non-smokers and smokers, would be suitable for health surveillance. However, the effects of dust exposure in smokers, although doubtless of statistical significance, were no larger than the standard errors of the variation about the regression lines, and even in non-smokers were not more than about half as large again as the corresponding standard errors. Thus, the mean standardized ICs for non-smokers exposed to less than 10 and more than 800 mpcf.y were 3.12 litres and 2.47 litres respectively, a difference of 0.65 litres, whereas the standard error was 0.58 litres. For smokers, the corresponding figures were: 2.81 and 2.43, with a difference of 0.38 litres and standard error 0.53.

5.4 Interrelationships of signs and symptoms

In the two foregoing sections, we have considered how various signs and symptoms were related to dust exposure. In this section, we examine their interrelationships. There seems to have been no study of how respiratory symptoms and lung function measurements were related in Quebec asbestos workers, and publications concerned with radiographic signs relate them only to function. A first report was made by Dr. M. R. Becklake and her colleagues to the 1968 Dresden conference; it was based on those members of the age-stratified sample for the physiology cross-section who were fully tested in 1967 (before its extension in 1968). This was superseded first by a summary report and then by a much fuller account with the same authorship (Becklake *et al.*, 1970).

The population studied consisted of all 1,069 men tested in 1967 and 1968. In other words, 54 men for whom data were incomplete were included, where possible, although they reduced the "physiology cross-section" to 1,015. This meant that the analyses were based on different numbers according to the function tests under review. The numbers of men included were as follows:- 1,062 for lung volumes; 1,059 for expiratory flows; and for diffusing capacities 840 (single breath), 1,049 (steady state), 932 (exercising at 200 kgm/min), 413 (at 400 kgm/min) and 149 (at 600 kgm/min).

It is implied (Becklake *et al.*, 1970, p. 641) that all 1,069 films for the complete population had been evaluated by each of the six readers, into the U/C classification. The subjects were themselves classified according to "the second highest reading" of small irregular opacities, the only parenchymal change of any importance because small rounded opacities were rarely recorded. Pleural change was taken as present if reported by at least two of the six readers.

As in the already discussed study of lung function measurements, these were "standardized" for age, height and weight by a complex regression procedure. The adjusted mean of each function measurement for the radiological group showing no parenchymal change (profusion of small irregular opacities 0/0; with six readers it would hardly occur that the second highest reading was 0/-) was taken as reference, and the mean for each other radiological group was expressed as a deviation from the reference. The effects of pleural changes were similarly assessed.

In those workers whose x-rays showed no sign of parenchymal disease, i.e. in the reference group, comparison with other populations suggested that VC and FVC might be slightly lower than "normal". In the presence of definite though minimal changes in the pulmonary parenchyma, VC and FVC were the only measurements to show "significant" reduction. Once more the word "significant" is being used in its statistical sense; for example, in those men whose profusion of small irregular opacities was, on the criteria given, 0/1, VC was over 95 per cent of that for the reference group. The authors write about function changes being "indicators of the progress of radiological disease" (Becklake *et al.*, 1970). The meaning is obscure, and what they are reporting is simply a matter of associations. Undoubtedly, VC was lower the higher the profusion of small irregular opacities, and there were several other tests which were similarly related, although they probably had substantially higher standard errors so that significance, in the statistical sense, was lower. Minute ventilation on exercise was selected by the authors as the most "sensitive" of the "indicators" other than VC. For any given grade of profusion of small irregular opacities, function was somewhat reduced when pleural thickening or calcification was also present.

5.5 Mortality in relation to asbestos exposure

Probably the most valuable of the Quebec chrysotile studies is the continuing evaluation of the effects of asbestos exposure on mortality. Tracing has been carried out to four points in time, and results have been presented in five reports, while one is in the final stages of preparation, *viz.*

Deaths to 31 October 1966	McDonald <i>et al.</i> (1971)
Deaths to the end of 1969	McDonald <i>et al.</i> (1973; 1974)
Deaths to the end of 1973	Liddell, McDonald and Thomas (1977)
Deaths to the end of 1975	McDonald and Liddell (1978); McDonald <i>et al.</i> (1979)

In a summary of the health of chrysotile mine and mill workers of Quebec, McDonald *et al.* (1974) wrote: "By the end of December 1969, 87.5 per cent of the 11,572 persons in the cohort [i.e. the "main mortality cohort"] and 99 per cent of those who had worked ten years or more had been traced. Of these, 3,270 had died, comprising 65.4 per cent of those born 1891 to 1895, but only 9.8 per cent of those born 1916 to 1920. The age-standardized mortality [i.e. deaths accumulated over the complete period of observation] per 1,000 men for certain causes of death are given in Table 3 [reproduced here as Table 5.2]. Cancer of the lung showed a rising rate with increasing dust exposure, particularly in the two highest dust exposure groups. Cancers of the gastro-intestinal tract also showed a rise in the two highest, and pneumoconiosis in the highest categories of dust exposure. Of 134 deaths in men from respiratory cancer, five were from pleural mesothelioma. These cases showed no clear relationship with dust exposure. There were no peritoneal mesotheliomas. Mortality from all causes fell with increasing dust exposure up to the highest dust group, probably because those who died young could not attain a high dust exposure. On the basis of Quebec death rates, the expected number of respiratory cancer deaths in the cohort was 139, or about 93 on the basis of estimated rates in the mining region. This suggests that mortality from respiratory cancer in the Quebec chrysotile industry as a whole has been at most 50 per cent above expectation and probably about

Table 5.2

MORTALITY TO END-1969
OF QUEBEC MINERS AND MILLERS

9,692 men in the "main mortality cohort"

(Cumulative mortality rates, per thousand men,
standardized for era of birth)

Accumulated dust exposure (mpcf.y)	C a u s e o f d e a t h			
	ALL CAUSES	Respiratory cancers *	Abdominal cancers	Pneumo- coniosis
Less than 10	365	10.3	18.0	1.6
10, less than 100	355	13.1	13.6	1.5
100, less than 200	354	13.4	18.7	0.8
200, less than 400	313	15.5	11.6	4.9
400, less than 800	323	21.4	26.3	4.9
800 or greater	395	32.1	28.7	23.6

* includes malignant pleural mesothelioma

25 per cent."

The earliest methods of analysis were known, from the start, not to have been ideal, and some improvements had already been incorporated in the reports of deaths to the end of 1969. In 1974, McDonald *et al.* stated that the first main weakness was that length of exposure might well have been related to length of survival - only those who survived say 30 years from first employment could have had 30 years of employment. The second lay in the use of deaths accumulated over many years (from 1910 to 1966) for a single calculation of mortality. An attempt had been made to overcome the first by use of a parametric approach due to Berry (1970), but this had not been entirely successful. One reason was that the two measures of exposure on which the analysis was based, i.e. years of employment and accumulated dust exposure, were so highly correlated that many of the 144 cells in the 4 x 6 x 6 array (four lengths of service, six groups of total exposure, six quinquennia of birth) were void or contained few men and hence no or very few deaths. The second weakness had been examined in 1973, by studying deaths 1967-69 separately - and finding essentially similar patterns. Nevertheless, an analysis based on man-years of exposure, what Case and Lea (1955) called "comparative composite cohort analysis", was planned. Meanwhile, a case-control analysis had already been adopted (Eyssen and Liddell, 1974), which, although only privately circulated because certain shortcomings were appreciated, suggested an important change in the approach to analysis.

So much importance was placed on finding the best methods of

analysis that it was felt desirable to seek advice from experts. This was done in two stages. First, a group met at McGill University in June 1974 to spend two days discussing methods of analysis. A full report (Liddell, 1974) was circulated; after it had been approved by all concerned, a brief summary was published (Liddell, 1975b). The second stage was to prepare an appraisal of methods of cohort analysis, using the Quebec mortality cohort data for applications, and to have this presented to a meeting of the Royal Statistical Society (RSS) where it could be discussed, and where paper, discussion and reply would be published (Liddell, McDonald and Thomas, 1977). Meanwhile, tracing was continued to the end of 1975, and what follows is a summary of these latest findings (McDonald and Liddell, 1978; McDonald *et al.*, 1979). They have been obtained using the methods discussed before the RSS, which appeared to find favour among the discussants who included several experts of impeccable reputation. There were two approaches, using argument *a priori*, from cause to effect, and *a posteriori*, from effect to cause. For the first, the cohort was divided into mutually exclusive sub-cohorts each subjected to Case and Lea's (1955) comparative composite cohort analysis, slightly amended in a Fortran program (PGMLA) written by Mario Rodrigues to my specification. This analysis accumulates man-years in view in each five-year square of the Lexis (1875) space, and calculates deaths expected on the basis of a reference population (here Quebec males) against which observed deaths can be compared. The ratio: $(\text{Observed deaths})/(\text{Expected deaths})$ can be seen to be a Standardized Mortality Ratio (indirect method), or SMR (Liddell, 1960; Liddell, McDonald and Thomas, 1977). The second approach follows Miettinen (1969) in selecting a fixed small number of controls

for each case; this has been shown to have high efficiency (Ury, 1975) and the material can be used for analysis by regression models (Cox, 1972) if required.

According to McDonald *et al.* (1974) the "primary aim has been to define as accurately as possible the quantitative relationship between exposure to chrysotile asbestos and the incidence of lung cancer"; this aim will be examined first. Thereafter, we will consider the evidence on mortality from all causes, pneumoconiosis, other exposure-related diseases, and mesothelioma. The classification of causes of death, coded in the Seventh Revision of the International Classification of Diseases, used throughout our recent studies is given below, in Table 7.1.

For the *a priori* approach, we adopted two classifications of sub-cohorts. In the first, four classes were created according to length of service: less than 1 year (3,007 men); 1 year, but less than 5 years (2,324 men); 5 years but less than 20 years (2,503 men); 20 or more years (3,105 men). Each class was then divided into four (giving 16 subcohorts in all) according to total exposure accumulated up to a maximum of 20 years, and all men who had survived 20 years from first entry to the industry were followed thereafter to the end of 1975. The reasons for these definitions are fully discussed by Liddell, McDonald and Thomas (1977).

In the second *a priori* classification, ten sub-cohorts were formed according to dust exposure accumulated to 45 years of age, and follow-up was from that age onwards. In order to investigate the

interaction with smoking, the ten sub-cohorts were subsequently regrouped into three, each subdivided by four levels of smoking.

In both uses of comparative composite cohort analysis the reference population was Quebec males. Full details of deaths annually by cause were available only from 1951 through 1973. The 1973 populations and deaths were reproduced as though they had occurred in 1974 and 1975 as well.

For the *a posteriori* approach, we chose four controls for each death from lung cancer. To be eligible, the control (a) had to be born in the same year as the case and to have survived into the year following the death of the case, and (b) had to have worked in the same mining area (Asbestos or Thetford Mines). One control for each case was selected as having similar smoking habit; three other controls without such restriction. Wherever choice was possible, it was made by strict application of a randomization procedure. Controls were found for all 245 lung cancer deaths (after excluding five mesothelioma deaths which had been coded 162-164 on the death certificate), the only relaxation in the criteria being that the first control was not always matched perfectly for smoking. The measure of exposure used in this analysis was dust accumulated up to nine years before the death of the case.

The findings from the three approaches to lung cancer mortality were in close conformity; they were also in very reasonable agreement with those reported earlier, even although those were on fewer deaths and by rather different methods. The Relative Risks in Table 5.3

Table 5.3

RELATIVE RISKS FOR RESPIRATORY CANCER AND ASBESTOS EXPOSURE
AT FOUR STAGES OF ENQUIRY

Accumulated dust exposure (mpcf.y)	1966	* 1969	1973	† 1975	Accumulated dust exposure (mpcf.y)
less than 10	1.0	1.0	1.0	1.0	less than 10
10, less than 100	1.1	1.3	1.2	1.1	10, less than 100
100, less than 200	1.5	1.3			100, less than 200
200, less than 300			} 1.0	1.2 {	200, less than 300
300, less than 400	} 1.2	1.5 {			300, less than 400
400, less than 600			} 1.8	1.8 {	400, less than 600
600, less than 800	} 2.1	2.1 {			600, less than 800
800 or greater	3.2	3.1	} 3.0	2.9 {	800 or greater

* Relative Risks for 1966 and 1969 were derived from cumulative mortality rates, standardized for era of birth.

† Relative Risks for 1973 and 1975 were derived from SMRs.
There were differences also in the definitions of exposure.

were all obtained by *a priori* analysis, but with differences in definitions of sub-cohorts and in methods of calculation, as already explained. However, a very similar dose-response relationship was demonstrated at each analysis (McDonald and Liddell, 1978).

Analysis of the case-control material, whether or not the matching was taken into account, indicated that a multiplicative model of the risk associated with smoking and with dust exposure fitted quite adequately. The corresponding *a priori* results are not open to such sophisticated methods of analysis, but do not suggest any alternative explanation.

The relationship of the response of lung cancer mortality by the end of 1975 to the accumulated dust dose in the 245 cases and their controls has kindly been examined by Mr. Geoffrey Berry, of the MRC Pneumoconiosis Unit. It is well fitted by the straight line:-

$$\text{Relative Risk} = 1 + 0.0012(\text{mpcf.y}).$$

The χ^2 statistic of 23.05 with nine degrees of freedom for differences between dust groups can be partitioned into a component of 19.61, with one degree of freedom, for the linear fit, leaving 3.43, with eight degrees of freedom, for departures from linearity. This last component is very small; further, there was no suggestion that any polynomial would improve the fit. Nevertheless, if only exposures up to 300 mpcf.y are considered, it is difficult to detect any excess lung cancer. The results from the 16 sub-cohorts, defined by length of service and average dust concentration, are compatible with either of these interpretations. Further analysis attempting to distinguish between possible models is in hand, but has so far produced no defini-

tive answer.

The exact form of dose-response relationship cannot be determined, but a linear relation is biologically plausible enough for malignant disease. Taking excess risk from respiratory cancer as linearly related to dust exposure in men who vary in their smoking habits, and to amount smoked in men from the same population who vary in their dust exposure, allowed McDonald and Liddell (1978) a rough comparison of the two hazards, by superimposing the relationships. This indicated that the Relative Risk of exposure to 1 mpcf for fifty years might be roughly equivalent to that from smoking three cigarettes a week during a similar period of life.

Relative Risks for a specific cause must, of course, be weighed in the light of overall mortality, otherwise they can be most misleading, as discussed by Liddell (1975c) in terms of a study by Sutherland (1959) of mortality from sinus cancer and lung cancer at a refinery in Port Colborne, Ontario. Sutherland's cohort was of 2,355 men employed for at least five years between 1930 and 1957, and he used the man-years approach of Case and Lea (1955), basing expectations on Ontario age- and cause-specific male death rates. He found Relative Risks of 36.8 for sinus cancer and 2.2 for lung cancer. However, the total number of deaths from these causes was only 26; the excess over expectation was 19. Meanwhile for all causes of death, the Relative Risk was 0.8; the cohort suffered in sum 63 fewer deaths than expected (245 compared with 308). On the more common causes of death (i.e. excluding those specifically studied) the Relative Risk was 0.7: the cohort suffered 80 fewer deaths than expected from these causes (219

compared with 299). The sinus and lung cancer deaths reduced this desirable shortfall by less than a quarter.

In the Quebec cohort, from 1951 to 1975, the number of deaths (all causes) expected, on the basis of provincial rates, was 3,328.2, almost equally divided between Asbestos (1690.2) and Thetford Mines (1638.0). There was a small excess, of about 39 deaths from all causes, at Asbestos and a rather larger one (of 182) at Thetford Mines. Respiratory cancer, in addition to showing the dose-response relationship discussed above, was also in excess of expectation, slightly at Asbestos and substantially at Thetford Mines (7 and 40, respectively). There was a total of 45 deaths from pneumoconiosis, among the 3,549 for all causes, and these are, at least in some senses, always an excess; 11 occurred at Asbestos and 34 at Thetford Mines.

The patterns with cancers of the abdomen were rather more complex. Those of the oesophagus and stomach were close to normal at Asbestos but in substantial excess at Thetford Mines (84 observed, compared with 54.41 expected). Cancers of the colon and rectum were only about three quarters of those expected, in both mining areas, but those of the organs in the abdomen were below expectation at Asbestos and above at Thetford Mines, although neither difference from expectation was very great. Other cancers were slightly above expectation in both places. Heart disease caused mortality very close to expectation in both places; so did stroke at Asbestos, although there was an excess of deaths from cerebro-vascular diseases at Thetford Mines. Tuberculosis deaths were close to expectation at Asbestos, but high at Thetford Mines (41 compared with 25.55 expected) while the deaths from

respiratory conditions not otherwise mentioned were slightly below expectation at Asbestos and slightly above in the other area. Accidental deaths were rather high at Asbestos and slightly above average at Thetford Mines; and deaths from other known causes below expectation at Asbestos and exactly as expected at Thetford Mines.

It was well known that dust concentrations had been considerably higher at Thetford Mines than at Asbestos and that service there had generally been longer. It was, therefore, to be expected that asbestos-related disease would be more common at Thetford Mines than at Asbestos. The dose-response relationship for lung cancer was very similar at the two places, and there were signs of dust relationships for cancer of the oesophagus and stomach, for respiratory tuberculosis and for other respiratory conditions, as well, as was to have been expected, for pneumoconiosis, these last being particularly clear.

Considerable effort has been given to the recognition of malignant mesothelial tumours not only in the cohort, but also in the population of the mining communities, either employees who did not meet the cohort criteria or those never employed by the mining companies. Ten male deaths in the cohort up to end-1975 were thought to be associated with malignant mesothelioma: only in three of these was it so stated on the death certificate; four were certified as "mesothelioma" and coded as benign; and three more were only discovered by study of autopsy findings. There is no easy way of arriving at an expected figure against which the ten can be compared, but from data obtained by McDonald and McDonald (1977), it was estimated to be about 2. In addition, there was one case in a female and, during 1976 and 1977,

four more cases in males. Thus, in all, we now know of 15 cases (all but one male) in the cohort, distributed as follows:- mine and mill workers: 10 at Thetford Mines and 2 at Asbestos; factory workers at Asbestos: 2 males and 1 female (McDonald and Liddell, 1978).

A final comment is required on female mortality. There were 440 women in the cohort; most had had short service, mainly in fairly low dust concentrations, so that very few had accumulated high dust exposures. Trace rates were higher even than for men, and there were fewer deaths than expected on the basis of provincial rates, i.e. 75 deaths from all causes in the years 1936-75 compared with 83.5 expected. By 1975, there had been two deaths ascribed to lung cancer (compared with one expected), but the excess was in fact a death due to pleural mesothelioma in a factory worker employed on the assembly of gas masks using crocidolite. Thus, there is no evidence of any excess mortality among female chrysotile workers, and they will not be discussed further in this thesis.

5.6 Mortality in relation to radiographic changes

A limited study was reported by McDonald *et al.* (1974). Among those traced up to the end of 1969 in the mortality study, nearly 10,000 were men; chest x-rays were available for a little over 5,000 of them, of whom 785 had died. Death rates were calculated by date of birth, accumulated dust exposure and the presence or absence of parenchymal or pleural radiographic changes.

For all causes combined, the death rate at Thetford Mines was increased in the highest dust exposure group but, after allowance for

exposure and date of birth, those whose radiographs showed parenchymal changes had higher mortality (220 deaths per thousand men traced) than those with normal x-rays (131 per thousand) or with pleural changes only (126 per thousand). A comparison was also made of deaths from respiratory disease, including tuberculosis and cancer. Similar methods of calculation showed 32 deaths in those with parenchymal change compared with only 8 expected, an excess of 24. Thus, 97 deaths in those with parenchymal changes on x-ray (with or without pleural changes) were observed, compared with 64 expected, an excess of 33, two thirds of them being attributed to respiratory causes. At Asbestos, the difference between the mortality of those with and without x-ray changes was less. There was a total of 431 deaths (all causes) but only 7 were associated with parenchymal change.

Further analysis of this material was not justified at that stage, because the number of deaths in those with chest x-rays was so small (785 out of 5,082, or only 15 per cent) and even at Thetford Mines, where dust exposure levels had been much higher than at Asbestos so that radiographic changes were to be expected more frequently, only 132 deaths were associated with x-ray change.

5.7 Summary

In male workers aged 36 to 65, the prevalence of radiographic changes rose with increasing dust exposure: of irregular small opacities (profusion 1/0 or more), from 2.2 per cent to 17.0 per cent; and of pleural thickening (grade 1 or more) from 1.4 per cent to 12.3 per cent. Small opacities or pleural changes were seen in 17 per cent of men; 3.2 per cent had both. Despite adjustment for higher dust

concentrations, the prevalence of radiologic changes was higher in the Thetford Mines area than in the Asbestos area. This was shown least by parenchymal changes, but was extreme with pleural calcification, which was common at Thetford Mines but virtually absent in Asbestos.

In 267 male miners and millers, each with five chest films spanning an average of 20 years, abnormality in the earliest film was related mainly to the time since first employment. In 30 per cent of the 150 men completely normal at earliest film, some radiological abnormality developed during the period of observation; in Asbestos, the risk of developing small opacities was lower in smokers than in non-smokers. There was an irregular pattern of correlation, more evident in Thetford Mines than in Asbestos, between radiological progression and various stimulus variables. The weak associations between radiological responses and measures of asbestos exposure indicated that effects were obscured by other factors (including susceptibility) uncorrelated with exposure.

An age-stratified random sample of 1,015 current male employees in the Quebec chrysotile mines and mills was subjected to a standard questionnaire and to lung function tests. The prevalence of persistent cough and phlegm (bronchitis) was related to age and smoking habits; in non-smokers and light smokers, it was perhaps also related to dust exposure. Breathlessness on exercise was related to age and dust exposure but not to smoking. In non-smokers, inspiratory capacity (IC), forced vital capacity (FVC) and forced expiratory volume ($FEV_{1.0}$) distinguished the lower two dust-exposure groups. In smokers, these tests were less sensitive.

The relationship between chest x-ray changes and pulmonary function was examined in basically the same sample. In workers whose x-rays showed no evidence of parenchymal disease, vital capacity (VC) and FVC may have been slightly reduced; in the presence of slight parenchymal changes, these measurements showed "significant" reduction. In addition, VC and exercise minute ventilation were related to radiological disease. For any given grade of parenchymal disease, function was somewhat more impaired when pleural thickening and/or calcification was also present.

Of 11,788 persons born between 1891 and 1920 employed in the Quebec asbestos mining industry, 88.4 per cent had been traced by the end of 1969, and 2,457 (23.6 per cent) had died. In the highest dust category, comprising 5 per cent of the cohort, the age-standardized rate was 20 per cent higher than in the other groups. Respiratory, cardiovascular and malignant disease accounted in equal proportions for the excess. There were 101 deaths from respiratory cancer (including three from mesothelioma), an estimated excess of about 15 deaths. The difference in rates of respiratory cancer between those maximally and minimally exposed was thought to be fivefold.

These patterns of mortality, exposure-response in particular, were essentially the same as those observed up to the end of 1975 (McDonald and Liddell, 1978). With almost half the men now dead and the survivors aged 55 to 84 years, it seems unlikely that further study will seriously modify the basic findings. As the latent period for malignant mesothelioma appears to be very long in these workers, we may expect the proportional mortality to rise somewhat from present

levels of 2.2 per 1,000 overall and 8.2 per 1,000 for men with 20 years or more exposure. However, the risk appears likely to remain very much lower than with crocidolite.

The major occupational hazards of chrysotile asbestos exposure are respiratory cancer and the complications of pulmonary fibrosis. Excess mortality from respiratory cancer has been shown to be directly related to accumulated dust exposure. The relationship may well be linear and a line also appears to describe the data for pneumoconiosis mortality and, indeed, for all causes.

Chapter 6

QUEBEC CHRYSOTILE FINDINGS AND OTHERS COMPARED

6.1 Introduction

The two other attempts to investigate health effects in Quebec chrysotile miners and millers are dealt with in section 6.2, followed by descriptions of other studies of workers in chrysotile only. Then we consider, in section 6.4, the relationships between dose (of exposure to asbestos of varying types) and response (of lung cancer mortality) and, in section 6.5, the interaction of asbestos dust and cigarette smoking. After a short discussion of mesothelioma, there are some summarizing comments on the health effects of asbestos exposure.

6.2 Other investigations in Quebec

In 1958, Braun and Truan published "An epidemiological study of lung cancer in asbestos miners". They attempted to collect data concerning all workers who had been "processed" through the clinic at Thetford Mines since its inception in 1947, and "similar" information at Asbestos. Because development of asbestosis in less than five years was considered rare, the cohort was defined as including every *miner* (my emphasis) who had a total exposure (? net service) of five or more years and was on the employment rolls in 1950; non-exposed

workers were excluded. Follow-up was over six years. The original cohort embraced 6,091 men, but 133 (2.2 per cent) were lost to view and "deducted". Of the 5,958 traced to presumably the end of 1955, a total of 187 had died (3.1 per cent), nine definitely and three possibly from cancer of the lung. After many tabulations and much discussion, the observed numbers of lung cancer deaths were compared with those expected from provincial rates on two bases, one ignoring age distributions but the other taking them into account and yielding an expectation of six deaths. Thus, the SMR was at least $9/6$, or 1.5, and it is difficult to accept the statement of the authors that "it seems fair to conclude that the asbestos miners in the Province of Quebec do not have a significantly higher death rate from lung cancer than do comparable segments of the general population".

In 1974-75, a group from Mount Sinai Hospital, New York, made a study among long-term employees of some of the mining companies at Thetford Mines. The findings were presented by Dr. W. J. Nicholson, on 27 February 1976, to the Quebec Government's Comité d'étude sur la salubrité dans l'industrie de l'amiante (Président: René Beaudry, j.e.p.) and recently to the New York Academy of Sciences conference on Health Hazards of Asbestos Exposure (Nicholson *et al.*, 1978). As results had been provided to the unions who commissioned the study, and had been published by the media, they were available for comparison with his own team's findings by Professor J. C. McDonald, at an International Conference on Lung Diseases in Montreal, on 18 May 1975.

The Mount Sinai study was much more limited than the McGill investigation. It was concerned, primarily, with 1,214 men at Thetford

Mines (much the dustier of the two mining areas of Quebec) who, with a few exceptions, had worked there for at least twenty years. Table 6.1 compares the radiological findings by Mount Sinai and in the two McGill studies (Rossiter *et al.*, 1972; Eyssen, 1975) of men with long service. Although the three studies presented here are not strictly comparable, the findings are fairly similar except in the estimated prevalence of minor degrees of parenchymal change. The Mount Sinai readers clearly placed many films into category 1 of the profusion of small opacities which the McGill group would have considered normal or doubtful. Differences of this magnitude in the difficult area of the boundary between categories 0 and 1 are not surprising when research methods are not identical. The Mount Sinai rates were based on the *consensus* of four readers who were *aware* that the films were all from men with at least 20 years of employment, some having been first exposed up to 65 years previously. These two aspects of design were contrary to the recommendations of a 1973 National Heart and Lung Institute Workshop on the chest x-ray as an epidemiologic tool (Weill and Jones, 1975). In the McGill studies, on the other hand, both series of films included a high proportion from men with little or no exposure; the readers knew only that the subjects had been employed at some time in the Quebec industry and they recorded their individual findings independently.

The Mount Sinai group also carried out a small mortality study, following 544 mine and mill employees from 1961 through 1973. The workers were divided (without definition) into "low" and "high" dust exposure groups, and for all causes of death the two groups had observed and expected deaths, and ratios, as follows:-

Table 6.1FINDINGS IN THREE RADIOLOGICAL SURVEYS
OF QUEBEC CHRYSOTILE MINERS AND MILLERS

Survey	Mount Sinai	McGill	McGill
Year	1974	1968	1974
Number of men	885	744	283
Mean years since first exposure	33	33	29
Prevalence (%) of:-			
small opacities			
profusion 1/0 or more	52	18	26
profusion 2/1 or more	5	6	8
pleural thickening			
grade 1 or more	20	12	21
pleural calcification			
grade 1 or more	10	12	10

Low dust exposure: 65 observed, 68.29 expected, SMR = 0.95

High dust exposure: 67 observed, 44.56 expected, SMR = 1.50

Deaths from specific causes are summarized in Table 6.2. One death from mesothelioma occurred - in the low exposure group - and has been included in "all other causes". The seven deaths from asbestosis in the "low" exposure group suggest that exposure was nevertheless substantial; a comparison of the expectations of deaths from all causes in relation to other material might indicate that the borderline between the two groups was taken somewhere around 1,000 (fibres/ml) \times years. Whatever the exact borderline, many of those in the "low" exposure group had had severe exposure by present-day standards, as indeed must have been true because of the length of employment and the high historical dust concentrations. Thus, that the SMR for all causes was less than unity in this group is of at least as much interest as the Relative Risks, comparing the higher exposure group with the lower, of $4.33/1.55 = 2.79$ from lung cancer, $1.11/0.72 = 1.54$ for gastro-intestinal cancer and $4.24/2.09 = 2.03$ for other respiratory conditions.

In Table 6.3, the Mount Sinai mortality findings are placed in context with those from the McGill investigation, where the latter figures relate to all men in the "main mortality cohort" with gross service of at least twenty years, divided into two sub-cohorts by average concentration (below and above 300 mpcf) over the first twenty years of employment. The larger numbers of the McGill investigation lead to much more reliable rates, and the Mount Sinai figures are seen to be in close conformity. This was only to be expected as the smaller study was essentially only a part of the McGill whole.

Table 6.2

MORTALITY AMONG 544 QUEBEC ASBESTOS
MINE AND MILL EMPLOYEES, 1961-73

Findings of Nicholson (1976)

(O = Observed deaths; E = Expected deaths; SMR = O/E)

	Low dust exposure			High dust exposure		
	O	E	SMR	O	E	SMR
Cancer:						
lung	7	4.52	1.55	13	3.00	4.33
gastro-intestinal	3	4.18	.72	3	2.71	1.11
other	4	6.75	.59	2	4.40	.45
Respiratory disease:						
asbestosis	7	*	*	11	*	*
pneumonia	1	2.01	.50	1	1.27	.78
other	2	2.79	.72	3	1.76	1.70
All other causes	41	48.05	.85	34	31.43	1.08

* Expectations low; SMRs high

Table 6.3

MORTALITY AMONG QUEBEC ASBESTOS
MINERS AND MILLERS

A: McGill study, 1910-75: 3,105 men with at least 20 years service

B: Mount Sinai study, 1961-73: 544 men

(O = Observed deaths; E = Expected deaths; SMR = O/E)

		Low dust exposure			High dust exposure		
		O	E	SMR	O	E	SMR
Cancer:							
lung	A	48	41.57	1.15	56	22.96	2.44
	B	7	4.52	1.55	13	3.00	4.33
gastro-intestinal	A	47	58.89	.80	45	33.02	1.36
	B	3	4.18	.72	3	2.71	1.11
Pneumoconiosis	A	11	*	*	25	*	*
	B	7	*	*	11	*	*
ALL CAUSES	A	620	657.88	.94	478	368.09	1.30
	B	65	68.29	.95	67	44.56	1.50

* Expectations low; SMRs high

6.3 Other studies of workers in chrysotile

In addition to the earlier reports from Russia, Cyprus, etc., there have been three recent accounts of mortality among workers exposed to chrysotile alone. The first discussed here concerns miners at Balengero, Piedmont, Italy, and was presented by Professor Giovanni Rubino and his colleagues at a meeting organised by the Royal Society of Medicine on 28 April 1977. The main concern was with 1,217 chrysotile miners followed from 1946 through 1975. All but 19 were traced (trace rate 98.5 per cent) and 336 were found to have died. The distribution of causes of death was similar to that in Quebec, except for excesses due to cirrhosis of the liver and cancer of the larynx, both comparatively common in Piedmont, and ascribed to heavy drinking of grappa. There had been one death due to mesothelioma.

Elwood and Cochrane (1964) described a follow-up study of workers from an asbestos factory near Cardiff, making mainly asbestos sheeting and pipe lagging, and using only chrysotile since 1935, although some crocidolite may have been used during 1933-35 in the manufacture of high-pressure pipes. Follow-up was of those alive fifteen years after exposure to asbestos dust. Deaths from all causes numbered 46 and those expected on the basis of mortality data for South-Eastern Wales were 47.87 (SMR = 0.96). For specific causes, the findings were:- neoplasm of lung, bronchus and pleura: 7 compared with 3.02 (SMR = 2.32); other neoplasms: 3 against 6.08 (SMR = 0.49); circulatory system 21 compared with 17.54 (SMR = 1.20); all other causes 15 when 21.23 were expected (SMR = 0.71). One death from mesothelioma was observed, but in a man who had probably worked with crocidolite. The authors concluded that chrysotile did not appear to be a

serious hazard as far as mesothelioma or abdominal tumours were concerned, though there was some evidence of an excess in the numbers of deaths from carcinoma of the lung and bronchus.

Weiss (1977) reported a thirty-year study of 264 men hired during 1939-45 who worked in a chrysotile products factory for at least a year and were alive at the start of 1945; follow-up was complete on 94 per cent. For all causes of death, the SMR was 0.61; for lung cancer and gastro-intestinal cancer it was 0.93 and 1.05, respectively. Although the SMR for all causes was higher for men who had worked at least five years in the factory compared with those who had had only one to four years employment, the difference in work duration had no effect on mortality from asbestos-related disease. Weiss concluded that men exposed to chrysotile alone showed a favourable mortality experience, but some caution in interpretation is necessary because of the very small numbers involved.

6.4 Asbestos dose related to the response of lung cancer

Although Schneiderman reviewed this subject in 1974, more data are now available, and this section attempts a synthesis.

Liddell, McDonald and Thomas (1977) published two analyses of the dose-response relationship of asbestos dose and lung cancer mortality in Quebec chrysotile workers. In certain ways, the most reliable estimate of the relationship was considered to be from an analysis in which each lung cancer death in the cohort was matched with five controls born in the same year as the case but who were alive at the end of the year in which the case died; dust exposures for cases and con-

trols were accumulated up to seven years before the death of the relevant case. Berry (1977a), using a minimum χ^2 , iterative, program of his own, obtained the equation of the line of best fit as:

$$\text{Relative Risk} = 1 + 0.001869(\text{mpcf.y}) \quad (1)$$

shown in the figure on p. 44 of Berry (1977b); a fit by eye had been made previously by the present author for other purposes, and this gave the regression coefficient as 0.001875. The χ^2 of 38.76 with nine degrees of freedom (Table 7 of Liddell, McDonald and Thomas, 1977) was partitioned by the fit of the line into 38.00 with one degree of freedom representing the linear trend and 0.76 with eight degrees of freedom for deviations from linearity; as Berry pointed out, this was almost too good to be true.

Because the dust exposure measures in these analyses were accumulated to seven years before the death of each case (and to the same age for his controls), there are some problems over treating the relations fitted in these terms as the most reliable. A more conventional approach, using *a priori* reasoning, i.e. arguing from cause to effect, grouped men according to their exposure and examined the SMRs of the groups. In Liddell, McDonald and Thomas (1977), 80 sub-cohorts had been defined in terms of length and place of service, accumulated dust exposure over twenty years, age at start of service and whether there had been substantial gaps in service. The SMRs for these 80 sub-cohorts clustered about the line given by (1), but the highest mean accumulated exposure in any sub-cohort was rather less than in the case-control approach so that the fit well away from the origin*

* The term "origin" is used as though the ordinate was excess risk, rather than relative risk.

could not be investigated.

McDonald *et al.* (1979) have used two definitions of sub-cohorts, allowing study of the corresponding relationships. The first grouping was into only 16 sub-cohorts, but using definitions exactly as previously for length of service and accumulated exposure; as was to be expected, the basic findings were closely similar to those found earlier. This time, however, the mean values of the accumulated dust exposures for each of the 16 sub-cohorts were obtained and it became possible to fit a line (by unweighted least squares)* to the SMRs, yielding the equation: $SMR = 0.9262 + 0.001343(\text{mpcf.y})$ or, expressed in terms of relative risk (RR),

$$RR = 1 + 0.001450(\text{mpcf.y}) \quad (2)$$

and the coefficient of correlation was + 0.87.

As already discussed in section 5.5, the minimum χ^2 fit by Mr. Berry to the latest case-control data yielded the line:

$$RR = 1 + 0.001193(\text{mpcf.y}) \quad (3)$$

and the χ^2 statistic with one degree of freedom for the linear fit was 19.61, leaving 3.43, with eight degrees of freedom, for departures from linearity. This last component is so small that it does not suggest any better non-linear fit, but it is now not "too good to be

* Although weighted least squares would have been theoretically more suitable, the complications were not considered justified as the differences would arise far from the origin, whereas the region of particular concern nowadays is close to the origin.

true". The slopes of lines (2) and (3) are in good agreement, when the errors of estimation, particularly of (2), are taken into account. It is not possible to "prove" that the relationship is truly linear, but the goodness of the fits (low residual χ^2 values, and high coefficients of correlation) and inspection of the data provide no justification for a curve approaching the origin at a more shallow angle.

The use of accumulated dust exposure as the only factor studied can be criticised, for it would appear to require the assumption that the risk of lung cancer did not depend on how the dust was accumulated: 500 mpcf.y could mean 50 years of exposure to a steady average of 10 mpcf, or 10 years to widely fluctuating concentrations averaging 50 mpcf, or indeed an infinite variety of patterns of exposure. However, there are several indications that it is a satisfactory choice. First, of those measures discussed by Liddell, McDonald and Thomas (1977, p. 478), this yielded the closest relationship with excess lung cancer mortality. Secondly, a comprehensive study by Dr. D. C. Thomas (personal communication) has failed to reveal any improvement in relationships by consideration of other factors describing how the exposure was accumulated. Thirdly, although there was some early evidence (Merewether and Price, 1930) and some recent speculation, for example by Enterline (1978 and earlier), that the more severe the exposure in terms of concentration, the shorter the latent period, recent evidence provides no confirmation; see Table 2.2 above.

Other studies of workers for whom measures of the dose of asbestos dust are available are rare. Berry (1977b) quotes the work of Enterline and colleagues (1972a; 1972b; 1973) among retired asbestos

factory workers in the United States, but there are two problems only one of which Berry attacked. This first was that even those retirees who had virtually no asbestos exposure produced a lung cancer SMR well above unity; Enterline's group also gave information about men who had retired from a factory nearby where there had been no exposure to asbestos, and the SMR here for lung cancer was similarly high. Berry (1977b, p. 45) related the lung cancer SMRs for exposed workers, taking account of accumulated dose, to those unexposed, and found a satisfactorily linear relationship; further the slope of that fitted line, when the relative risk at zero dose was taken as unity, was quite similar to that of line (1) above. The second problem is more difficult: in one of their reports, Enterline *et al.* (1972b) stated that 1,026 of the retirees from the asbestos factory had been production workers, three-quarters of whom had been exposed only to chrysotile, whereas 438 had been maintenance or service workers and a fairly high proportion of these had been exposed to crocidolite. The dose-response relationships in the two groups were quite dissimilar, being virtually non-existent for the production workers when the device was adopted of comparing against unexposed workers from the non-asbestos plant. However, the other group showed a *curve* which was always much above the line fitted to the whole cohort, undoubtedly significantly so despite small numbers. Publication of a more detailed breakdown of the cohort according to the type of fibre to which they had been exposed (Enterline and Henderson 1973) confirmed differences between fibre type in the risks of lung cancer but did not provide information on dose to allow adequate investigation of the shapes and slopes of the relationships.

A recent mortality study of workers engaged in the manufacture of asbestos-cement products in Louisiana has so far been published by abstract only (Hughes *et al.*, 1978) and full detail is not yet available. However, 5,654 males with at least one month employment were followed for a minimum of twenty years. Tracing, through the Social Security Administration, was complete for only 76 per cent, and only 90 per cent of death certificates were obtained. It was reported that SMRs for total mortality were less than in the State of Louisiana, and that the only cause of death found to be dose-related was respiratory malignant neoplasms "with significantly increased SMRs (225, 187) in the two highest exposure categories (> 100 mpcf.y)". Men with service less than two years had no excess mortality, those with from two to ten years service had increased mortality only when average dust concentrations were greater than 20 mpcf, and those with ten or more years service had increased mortality when concentrations were greater than 5 mpcf. It is not stated in the abstract to which fibre(s) the cohort had been exposed.

There have been several reports on a factory at Rochdale (Knox *et al.*, 1965; 1968; Howard *et al.*, 1975; Peto *et al.*, 1977) but, although some environmental evidence has been given, it does not allow full examination of dose-response relationships. From the 1975 paper, it was possible to gain the impression that working conditions in this factory had been more-or-less in accord with present day standards for many years. The facts are far different, as could have been inferred from the 1968 paper and as now given in the latest (1977) paper. Men and women first exposed in 1951 or later numbered 347; of these six men died from lung cancer when only 3.2 such deaths were to have been

expected from national mortality rates; the SMR was thus 1.9. However, we are also told (Howard *et al.*, 1975) that five of the six lung cancer deaths were in men who had been working in areas where dust levels were high in 1952. Equal allocation of the man-years to higher and lower dust conditions provides the following:- lower dust concentrations: one death against 1.6 expected (SMR = 0.63); higher dust concentrations: five deaths against 1.6 expected (SMR = 3.13). Further all six cases were smokers.

Dr. M. L. Newhouse, in a series of papers with various colleagues, has reported *seriatim* on mortality of workers at the Cape Asbestos factory in Barking. Although dust concentrations were only classified in two ways (low-moderate; severe) and service likewise (less than two years; longer), there were large differences in SMRs among 1,414 men followed from twenty years after start of service (Newhouse, 1973a), *viz:-*

	Dust concentration	
	<u>Low-moderate</u>	<u>Severe</u>
Less than 2 years in the job	4/2.4 = 1.67	11/3.3 = 3.33
Longer in the job	5/1.6 = 3.13	17/2.3 = 7.39

Comparison with other experience is impossible without estimated concentrations, but the excess risks appear much higher than in Quebec. There can be no doubt that substantial amounts of crocidolite were used at this factory.

6.5 The interaction of asbestos dust and cigarette smoking

Saracci (1977) has reviewed the epidemiological evidence on the asbestos-smoking interaction, considering three models. In the first,

the excess incidence of lung cancer independently due to asbestos and to smoking add together when both agents are present (additive model). In the second model, the addition of each one of the two agents produces an increase in lung cancer incidence which is proportional to the effect of the other agent (multiplicative model). In the third, asbestos can increase lung cancer incidence only in the presence of smoking. Saracci did not have available at the time of writing the data from Quebec, but he reviews the rest carefully. As found by other investigators, he feels the additive model the least plausible of the three, and the multiplicative the most plausible.

The evidence from Quebec also supports the multiplicative model, and here the amount of data make the plausibility the greater. In studies based on *a priori* reasoning, there appeared little to suggest deviation from the multiplicative model. Thomas (1977) reported on his preliminary studies of the shapes and forms of relationships and interactions on lung cancer deaths to the end of 1973. His more recent work (Dr. D. C. Thomas, personal communication), using two methods of analysis, showed no evidence against the multiplicative model: in unmatched analysis of the case-control data (cases to end-1975 with four controls per case, one chosen matched for smoking habit, the other three not so matched), using multidimensional contingency table analysis, he found no significant improvement to the fit by varying the model from the simple multiplicative. In a matched analysis based on his own extensions of methods, following Cox (1972) and others, to be published (Thomas, 1978), he once more demonstrated a good fit of the multiplicative model to the data.

An important finding from Quebec is that of the 245 male lung cancer deaths, 20 were among non-smokers. While there remain some doubts about the quality of some of the smoking information obtained from the questionnaires, they relate mainly to the coding, the lack of information about men who died before 1950, and the inevitable problems about deciding who is an ex-smoker when the respondent may revert to smoking after being questioned. The exact amounts smoked may also be in doubt, but perhaps the most reliable piece of information is the statement that a man never smoked. In the non-smokers, the observed relationship between dose of asbestos and excess lung cancer was similar to that in smokers. This would seem to dispose of the third of Saracci's models.

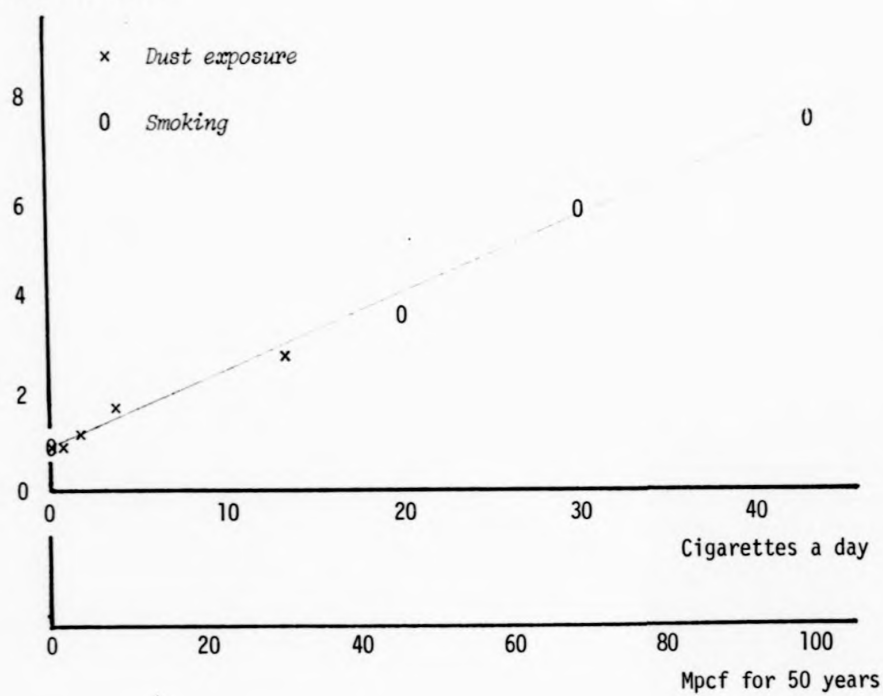
Figure 6.1, following McDonald and Liddell (1978), takes excess risk from respiratory cancer as linearly related (a) to asbestos dust exposure in men who vary in their smoking habits and (b) to smoking in men from the same population who vary in their dust exposure, and superimposes the relationships, to allow a *rough* comparison of hazards.

6.6 Mesothelioma

This thesis is not primarily concerned with mesothelioma, and there is a good review of the whole subject by McDonald and McDonald (1977). However, the importance of fibre type cannot be overemphasised and it seems necessary to discuss the incidence of this condition in those exposed to chrysotile alone.

In studies among Quebec workers, McDonald and Liddell (1978) reported a total of fifteen deaths (all but one male) due to mesothelioma, to the end of 1977. They were distributed as follows:- mine and mill workers: ten at Thetford Mines and two at Asbestos; factory

Relative Risk



LUNG CANCER MORTALITY BY DUST AND SMOKING

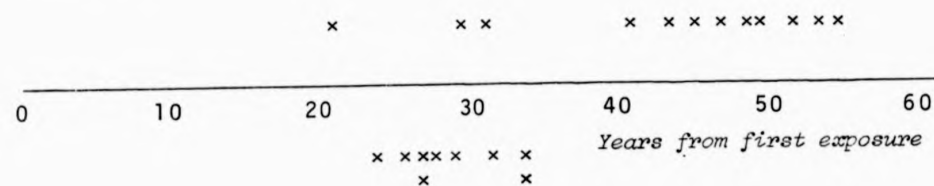
Figure 6.1

workers: three, including one female, all at Asbestos. Figure 6.2, also from McDonald and Liddell (1978), shows the twelve cases in miners and millers by interval from first employment, and nine cases in persons employed in Canada in World War II on the crocidolite filter pads for service gas masks (McDonald and McDonald, 1978). Two of the factory workers at Asbestos were involved in this process and are included in the lower part of Figure 6.2; the third factory worker may also have been exposed to crocidolite during the same period but is not included. This figure shows that, in the chrysotile mine and mill workers, the median period from first employment to death was nearly 20 years longer than in the factory workers exposed to crocidolite. Other differences were also impressive. Of the twelve "chrysotile cases", nine were in 3,105 men employed twenty years or more and three in 7,834 men employed less than twenty years; all twelve were pleural. The nine "crocidolite cases" were in total of only 199 persons, none of whom had worked in gas mask production for more than 2½ years; six of the nine cases were peritoneal.

Of the nine mesothelioma deaths to the end of 1975 that might be considered due to exposure to chrysotile, seven were at Thetford Mines; none were in men with the highest dust exposures, but there was lower incidence among those more lightly exposed at Thetford Mines. In his study in the same area, Nicholson (1976) reported only one mesothelioma among 132 deaths, a rather higher proportional mortality, but still a rare occurrence. This death was not in the group that Nicholson designated as "high" dust exposure, but as already discussed his "low" dust exposure group surely included many men with substantial exposures by to-day's standards.

Figure 6.2LATENT PERIODS IN MESOTHELIOMA

Miners and millers: CHRYSOTILE



Factory workers: CROCIDOLITE

It is difficult to obtain an estimate of the number of mesothelioma deaths to be expected in the "main mortality cohort", particularly because of the high ascertainment rate in the Province of Quebec (McDonald and McDonald, 1977), but it seems not unreasonable to put it at about two for the miners and millers. Thus, there were four to five times as many deaths from mesothelioma as expected; it remains essential to keep the absolute number in mind, particularly in relation to the numbers of deaths from lung cancer (245 among men) especially those that might be considered asbestos-related (about 45 or 50).

Of the 336 deaths among Piedmont miners, Rubino reported one mesothelioma, a proportion quite close to that observed in Quebec. Elwood and Cochrane (1964) also reported one mesothelioma, but thought it was due to crocidolite exposure; Weiss (1977) observed no deaths from mesothelioma in his small cohort of chrysotile factory workers. Although Peto (1978) reported only pleural mesotheliomas from the Rochdale factory, crocidolite had been used there, although in what quantities is not known. All other occupational studies with high proportional mortality from mesothelioma have been in persons exposed to amphibole fibres. In all these studies the absolute numbers have been high, and there have been high proportions of peritoneal tumours.

6.7 Summary

In an important "State of the Art" review, Becklake (1976) listed (her Table 1) the pathological effects of asbestos exposure in man, differentiating between effects that are established, associated with a co-factor, possible and remotely possible, as follows:- established: asbestos bodies and/or fibres in the lung; asbestosis; pleural plaques

and calcification; pleural and peritoneal mesothelioma; and neoplasia of the gastro-intestinal tract; adding carcinoma of the lungs as a co-factor with cigarettes. As possible effects, she included carcinoma of the larynx, pleural effusion; as remotely possible, carcinomas of ovary and breast. For completeness, one should also mention asbestos corns, although they are not relevant to this thesis.

In her Table 4, Dr. Becklake listed studies that have demonstrated dose-response relationships between biological responses in man and estimated exposures, pointing out that most of the measures of exposure have been rather crude, including: years of exposure; years since first exposure; occupation; occupation and duration. The studies in Quebec chrysotile workers are nearly unique in having related responses to accumulated dust exposures, but there are two added studies by Weill and his colleagues (1973; 1975). Radiological changes both in the parenchyma and in the pleura have been found to increase with increasing dose, however measured. Lung function measurements, particularly FVC and $FEV_{1.0}/FVC$ have often also been related to duration of exposure, and symptoms, particularly breathlessness on exercise, to dust exposure. These signs and symptoms are of course only "signposts" on the way to excess mortality, and this in turn has frequently been related to measures of exposure, with excesses especially noticeable for lung cancer, sometimes gastrointestinal cancer, occasionally laryngeal cancer, and, where numbers or fibre type have made it possible, mesothelioma. However, the ability of the signs and symptoms themselves to predict excess mortality has not been the subject of such close study. In particular, the essential relationship between radiological change and excess

mortality has been examined so far only to a very limited extent in a general review of the health of Quebec miners and millers.

Chapter 7T H E S I S O B J E C T I V E S
A N D M A T E R I A L S7.1 Introduction

Although there is no doubt that exposure to asbestos dust can, if severe enough, lead to premature death, little is known about how the various signs and symptoms make themselves apparent during the disease process. All have been shown to be interrelated, but there is little evidence of whether radiographic changes, depressed lung function or breathlessness are generally the earliest, or how any of them predict mortality. None of the various function tests and none of the respiratory symptoms can be considered specific to asbestos-related disease; on the other hand, x-ray changes that can be categorized into a "classification of the pneumoconioses" devised with particular concern for asbestosis must be taken as more specific. Thus one form of validation of a classification is in the extent to which radiological changes can predict mortality.

Other possibilities of validation are in relating *post mortem* pathology to radiographic appearances in an x-ray taken shortly before death; or, alternatively, in high correlations between appearances, say, in employed workers and measures of their exposure during relevant periods before the x-ray. However, correlations of this latter nature,

although positive in many studies in asbestos workers and in those exposed to other mineral dusts, have never been high enough to provide acceptable validation. In coalworkers, several attempts at validation of x-ray classifications in terms of *post mortem* findings have been made, but mainly in the same lungs (Liddell, 1972; Rossiter, 1972b and in several other reports). These authors concluded that the observed correlations between the profusion of small rounded opacities and the weights of various chemical dusts assessed in the lung were high enough to justify a claim that the ILO, Geneva, 1958, classification was of reasonable validity. However, this was only for coalworkers, and in any case was concerned with a now outdated radiological classification. As Rossiter (1972c) has pointed out, coalmine dust is relatively inert, and in considering the biological effects of asbestos in the lungs, pathological assessment would have to take into account the fibrosis rather than the dust itself. A study to this end has recently been put in hand in the Province of Quebec, but results cannot be expected for several months, and can at best be provisional only - because of the ways in which (a) cases have been selected and (b) assessments, both histological and radiological, have been made.

Although the National Coal Board's Pneumoconiosis Field Research (PFR), set up in 1952, had rather restricted objectives (Fay and Rae, 1959) concerned with the setting of dust standards in the light of radiological change (later extended by consideration of lung function), investigation of mortality was made feasible in the late 1960s, when National Insurance numbers for all men ever included in PFR were incorporated into the record-keeping system, to make it compatible with that introduced for the Board's Periodic X-ray Scheme (PXR) at its

inception in 1959 (Rogan, 1964; Liddell and May, 1966; Lee, 1966; Mead, 1966). Meanwhile Cochrane *et al.* (1964) had carried out a six-year mortality follow-up of males over 15 originally surveyed in the Rhondda Fach in 1952; an earlier study, with only two-and-a-half years of follow-up had been too short to carry much conviction. Although non-miners had lower SMRs than miners, there appeared to be no differences in the SMRs of those whose 1952 x-ray had been placed in any of the categories 0, 1, 2 or 3 of simple pneumoconiosis in the Cardiff-Douai or, for all practical purposes, the ILO, 1958, classification. Indeed, the only predictive value of the x-ray seemed to be that those with progressive massive fibrosis in 1952 had higher SMRs than those with normal x-rays or simple pneumoconiosis only. This was, at least to the present author, a rather surprising finding, which might have been due to several factors, including the rather short period of follow-up and the very special population examined. The former, but not the latter, was overcome in a follow-up of the same population for twenty years, reported by Cochrane (1973). However, the main finding was similar: "Survival rates for miners and ex-miners appear independent of the x-ray category of pneumoconiosis except for category B or C, where survival rates are much reduced". More recently, Jacobsen (1976) produced essentially the same result in a rather larger study, based on all 35,000 miners in the original PFR surveys; nevertheless, the yet larger, and completely representative, sources of PXR have still to be tapped.

These findings in coalworkers were not in accord with those reported by McDonald *et al.* (1974) in asbestos miners and millers; see section 5.6 above. The differences probably lie mainly in the dif-

ferent types of dust to which the subjects were exposed; the radiographic changes associated with asbestos exposure are not common in coalworkers, and certainly were not recognized in the classifications of radiographs used in both Cochrane's and Jacobsen's studies of coalworkers.

7.2 Objectives

In all these circumstances, it seemed of great importance to attempt to answer the question:

1. To what extent can radiological changes in those who have been exposed to asbestos dust predict mortality?

This, then, was the primary objective of the thesis research. Its justification was confirmed in the recent deliberations of eight distinguished film readers (from Germany, Italy, South Africa, the United Kingdom and the USA) who carried out a trial in Johannesburg during October 1977 of the ILO U/C (1971) classification for use specifically in asbestos workers (Irwig, 1978). Under the heading "x-ray abnormality and health impairment", these readers agreed that the morbidity and mortality associated with x-ray abnormality were largely unknown. They felt research in this area to be crucial, because the importance of radiology depends on its ability to predict illness and death, rather than on its sensitivity to asbestos exposure.

As some predictive ability was to be expected in the light of the findings reported by McDonald *et al.* (1974), two further questions arose:

2. Are the predictions of mortality from radiological changes improved or modified by other factors?
3. What are the best factors for predicting mortality?

7.3 Factors for study

The choice of factors for study, other than radiological changes, could only be made in the light of knowledge from mortality studies in exposed workers and in others, and in relation to the causes of death that it would be reasonable for radiographic change to predict.

The asbestos-related causes of death have been seen, from our own studies, to include pneumoconiosis and lung cancer, both of which might well be detected on the chest x-ray. Death certified as from respiratory tuberculosis and other respiratory conditions might also be radiologically diagnosable whether or not associated with dust exposure. Other diseases, including cancer of the oesophagus or stomach, or of the colon or rectum, and diseases of the heart, might well not be diagnosable on a chest x-ray, but if they were associated with heavy dust exposure, such exposure might have led to pneumoconiotic appearances in the radiograph. It was therefore felt necessary to differentiate all the above causes of death in the various analyses. It was also, of course, important to study deaths regardless of cause, while certain other groups (laryngeal cancer, "other" abdominal cancers, "other" cancers, accidents and cerebro-vascular diseases) were also differentiated, together with those where the cause was known but did not fall into any of the other defined categories. Inevitably, a precise cause of death would not be determined for a few deaths, which could not be placed into any of the thirteen defined groups of causes,

but were, of course, included in the counts of total deaths, or "deaths from all causes". Our classification of causes of death is given in Table 7.1.

As far as dust-related diseases were concerned, our own studies in Quebec had shown the undoubted importance of measures of exposure based on estimates of dust concentrations. Although no differences had been found between Asbestos and Thetford Mines in any of the mortality studies (except those concerning cancers of the gastro-intestinal tract) after due allowance for the substantially heavier and longer durations of exposure at the latter, there were some differences between the places in radiological findings. It was therefore felt it would be necessary to distinguish them again. Smoking was clearly important as far as lung cancer was concerned and might be expected to have associations with mortality from certain other causes.

No evidence was available from the Quebec studies about mortality in relation to respiratory symptoms and lung function, but these were known to be related both to dust exposure and to radiographic changes, while there was evidence from population studies, mainly in the USA, concerning mortality in relation to respiratory function and symptoms (see Chapter 14, below).

The remaining issue is of the length of follow-up. Were the objective to validate the x-ray classification against pathological findings *post mortem*, the x-ray should have been taken as late in life as possible, to leave the interval between x-ray and *post mortem* short. However, for a realistic test of the effectiveness of the x-ray in

Table 7.1

CLASSIFICATION OF CAUSES OF DEATH

(The codes are those of the Seventh Revision of the International Classification of Diseases)

Pneumoconiosis	523-524
Cancer of the chest	162-164
162: malignant neoplasm of bronchus and trachea, and of lung specified as primary; 163: malignant neoplasm of lung, unspecified as to whether primary or secondary; 164: malignant neoplasm of mediastinum.	
Tuberculosis of respiratory system	001-008
Other respiratory conditions	470-522; 525-527
470-475: acute upper respiratory infections; 480-483: influenza; 490-493: pneumonia; 500-502: bronchitis; 510-527: other diseases of respiratory system other than pneumoconiosis.	
Diseases of the heart	400-443
400-402: rheumatic fever; 410-416: chronic rheumatic heart disease; 420-422: arteriosclerotic and degenerative heart disease; 430-434: other diseases of heart; 440-443: hypertensive heart disease.	
Cancer of oesophagus or stomach	150-151
Cancer of colon or rectum	152-154
Malignant neoplasm of small intestine, including duodenum, of large intestine or rectum.	
Other cancers of the gastro-intestinal tract	155-159
Malignant neoplasm of biliary passages, liver, pancreas, peritoneum or unspecified digestive organs.	
Cancer of larynx	161
Other malignant diseases	140-148; 160; 165-205
Cerebro-vascular diseases	330-334
Vascular lesions affecting central nervous system	
Accidents, including poisonings and violence	800-999
Other known causes	All codes not listed above

predicting mortality in a working population, the follow-up period has to be rather longer. In diseases where the interval between diagnosis and death is very short, e.g. mesothelioma or to a lesser degree cancer of the lung, it then becomes unlikely that any direct validation of radiographic classification would be possible, as abnormal appearances specific of the terminal condition could hardly have appeared at the start of the follow-up period, usually substantially before diagnosis. In these circumstances, it becomes necessary to rely on indirect validation, i.e. prediction by means of radiographic changes not themselves typical of the condition in question but rather associated with the asbestos exposure, which at least in some of the cases may have led to the terminal disease.

7.4 Criteria for selecting a study population

The ideal criteria for choice of an acceptable study population can thus be listed as follows:-

- (1) a chest x-ray towards the end of a person's employment; further, the x-ray should have been assessed, independently, by each of several readers (Weill and Jones, (1975), into a standard, but detailed, classification of pneumoconiotic appearances, including those of asbestos-related disease;
- (2) a full work history, including estimates of dust concentrations, to allow calculation of measures of exposure;
- (3) smoking history;
- (4) lung function measurements and evaluation of respiratory symptoms close to the time of x-ray;

- (5) complete follow-up for long enough that a substantial proportion of the population has died; and, for each death, date and certified cause.

No population could be ideal, and to carry out an entirely new study on an adequate scale would have been prohibitively expensive. However, it was possible to select two cohorts, "A" and "B", of Quebec miners and millers, both of which met many of these criteria.

Cohort "A" was intended to consist of all 1,015 men in the "physiology cross section" (see section 4.7 above) defined by both McDonald, Becklake *et al.* (1972) and Becklake *et al.* (1972): these men were still employed by the mining companies in Quebec in November 1966, full work histories to that point were available, and the last employment medical examination x-ray up to that time had been selected and read by six readers; smoking history, and respiratory symptoms had been elicited by questionnaire in 1967 or 1968, and lung function measurements made at that time; about two-thirds of the men had been born between 1891 and 1920, and so they were embraced in the "main mortality cohort" (see section 4.6 above) leaving only about one-third requiring to be followed. However, although the sample had been weighted (by stratification) towards older men, some of whom were close to retirement, most would have continued in employment, probably in the mining industry. Nevertheless, additional exposure beyond 1966 was to concentrations of dust at much lower levels than had been in existence for most of the men in earlier years, so that the increment was likely to have been at a low absolute level, although for many of the younger men it would not have been low in relative terms.

Cohort "B" consisted initially of all those persons in the "main mortality cohort" who had also had a radiograph assessed during the major reading studies of 1967. Well over 5,000 workers were expected to be in this group, but it was reduced for three reasons. First, to ensure the greatest degree of comparability, only those persons whose film had been successfully read in what Rossiter *et al.* (1972) called stage 2, i.e. by one of the six readers, after randomization into as nearly as possible equal sets, but excluding films considered "unreadable". Secondly, to preserve independence, the 603 men common also to Cohort "A" were excluded. Thirdly, the 231 women remaining at this point were excluded, after preliminary examination had confirmed (a) that they had in general had low exposures to asbestos, (b) that all but a few of their films had been assessed as completely normal, and (c) that the SMR, in relation to all women in the Province of Quebec, was considerably less than unity, in fact 0.78. In Cohort "B", we did not know the date of the last x-ray, but could assume that criterion (1) had been met as to the timing of the film, although only one assessment of each was available. Criteria (2) and (5) were met completely, by virtue of membership of the mortality cohort, and (3) partially so; there were no lung function measurements or assessments of symptoms.

Further details of the two study cohorts - definitions, sources of data, assembly of data, and numbers by follow-up status (alive at the end of the follow-up period, known to have died, or lost to view) - are given in the next two sections.

7.5 Cohort "A": definition, sources and numbers

The "physiology cross-section" described in section 4.7 above has been reported on by Becklake *et al.* (1970), who studied lung function in relation to radiological changes in 1,069 men, and by McDonald, Becklake *et al.* (1972) and by Becklake *et al.* (1972), studying respiratory symptoms and lung function in relation to dust exposure, who found it necessary to exclude 54 men for whom data discrepancies had been discovered, to leave a study group of 1,015. The magnetic tape files containing the function measurements, with heights and weights, and the questionnaire responses, were known as LUNF2F and QUESTF, respectively. Matching of LUNF2F against QUESTF indicated that all 1,071 persons on the first were also on the second, which contained records for eleven additional subjects who, presumably, had attended for interview but had not completed satisfactorily the tests in the mobile laboratories. The present concern was with males only, and so 40 females on LUNF2F were excluded. Thus, at that point, the population for study consisted potentially of 1,031 men.

The first stages of follow-up had been instituted early in 1977, making use of a list of 1,015 men, kindly supplied by Dr. Margaret Becklake, and purporting to relate to those included in the studies reported in 1972. The men were classified as to whether they were or were not in the mortality cohort, i.e. had been born in the years 1891 through 1920, or more recently - as all in this population had been at work in 1966, none could have been born before 1891. Arrangements were made for the tracing of those not in the mortality cohort. This work was carried out by Mrs. Proulx, at Asbestos, and Mrs. Beauchemin, at Thetford Mines, two ladies who had been specially trained for such

tasks over a number of years. However, the initial classification had been almost entirely by the date of birth given on Dr. Becklake's list, and that included any amendment made during interview in 1967 or 1968. Further, the list took no account of changes in the cohort since it was first prepared in about 1969, and so the classification required careful checking, which revealed several men who had been wrongly treated recently as part of the mortality cohort, i.e. who would now have to be traced; the field enquiries had also to be extended to cover those among the 1,031 men on LUNF2F who were not on Dr. Becklake's list. In fact, one of these could not be identified in the register either; we could find no trace of him in any of our data banks (except LUNF2F and QUESTF) and he was therefore eliminated from the study population at this stage. Meanwhile, every case in the "main mortality cohort" was positively identified: they totalled 624. This left 406 for follow-up, which was carried into the start of 1976, to bring it into line with that for the mortality cohort proper.

In the event, tracing was complete: as these men were all born after 1920, it was not surprising that most were alive. There had been eleven deaths, and dates and places, all in Quebec, were obtained. A request for copies of the death certificates was refused by the Quebec government, because of a new attitude to confidentiality; nevertheless, a satisfactory cause of death was obtained by further enquiry by Mesdames Proulx and Beauchemin. The eleven new causes of death were coded into the Seventh Revision of the International Classification of Diseases, in conformity with the practice for the "main mortality cohort"; see Table 7.1.

Several processes were needed to identify sets of x-ray readings for these 1,030 potential subjects, i.e. the 1,031 men on LUNF2F less one unidentifiable as described above. The identifying number was a 6-digit number which had been entered on the buff cards at the time of registration in 1966-67; for those men found to have more than one buff card, the number relating to his latest employment was on the LUNF2F record, but for most other purposes a special number, in less than six digits, had been used for the subject with appropriate cross-reference to the several six-digit numbers on the two or more buff cards recording his history. Usually, it was this shorter ID that had been used on the intermediate magnetic tape file, TRIPLF, from which the film reading number had to be extracted. Great care had to be taken to ensure that the search of TRIPLF was truly comprehensive; many checks were possible and all were instituted. Nevertheless, 21 men could not be traced on TRIPLF, which meant that it would not be possible to find any radiological assessments for them. This left 1,009 men in the study, the same number as had been come to in an earlier attempt at reconciliation (White *et al.*, 1974).

Next, the magnetic tape file (BASICX) containing over 42,000 x-ray readings had to be searched for any reading against the appropriate number for each of the 1,009 men still in the population; at least one reading was indeed found for every subject. In most cases, there was a set of six readings (one for each reader), together with a "stage 2" reading, and often additional readings from later stages of the radiographic study. However, for a total of 19 subjects, it was not possible to find or make up a set of six readings, one by each of the different readers. The potential study population was now

reduced to 990.

For these 990 men, we brought on to one magnetic disc file all the desired information from LUNF2F and QUESTF, together with the six radiographic assessments and, for men not in the mortality cohort, the tracing information, including, where appropriate, date and cause of death.

For those in the "main mortality cohort", it was comparatively simple to bring forward, from the magnetic tape records of that cohort, not only the tracing details, i.e. status (alive, dead or lost to view) and date of death (or loss) with cause of death, but also the fully detailed record maintained on what was called the Final Analysis File of the mortality study (Rodrigues, 1976). There remained the corresponding details of work history for men not in the mortality cohort. The details from the buff cards for all persons registered in 1966-67 but not included in the mortality cohort had been punched onto cards and transcribed, in "mirror image" without editing, on to what was called the Bonaventure magnetic tape. It might therefore have seemed a small task to obtain the work histories, for the 406 persons involved, in the same lay-out as for the remainder. However, this had been a laborious aspect of the original data processing (Rodrigues, 1976) and we needed access to many programs in the original suite, some of them used iteratively, and two more had to be written. Much checking was necessary, pinpointed by the computer programs, but rendered slow in execution because of fairly extensive clerical work, key-punching and verification, carried out by the author, while the basic records were held at an outstation. Some indication of the data processing involved

is given in Table 7.2; it was completed for all but one man whose buff card record was not on the Bonaventure tape, while the card itself could not be found in late 1977.

The detail carried forward to this stage was very long, so that costs for disc storage and for analytical computing would have been unnecessarily high. Three major savings were achieved. First, after record linkage had been successfully completed, unneeded identifying detail was eliminated; secondly, the environmental history was reduced to the totals of net service and of dust exposure accumulated to November 1966; and, thirdly, the information on symptoms and lung function measurements was reduced to a working minimum, in consultation with Professor Margaret Becklake and my supervisor. Other, smaller, savings would have been possible, but it was not felt they were worth the extra costs of rewriting the files in further shortened form.

The basic information retained on the working file (XMAFWF) is listed in Table 7.3. The symptoms and measurements recorded in 1967 or 1968 were as defined by McDonald, Becklake *et al.* (1972) and Becklake *et al.* (1972). Smoking was recoded into a single character six-point code as follows:- 0 = Non-smoker; 1 = Ex-smoker; 2 = Not a cigarette smoker; 3 = Smoker of 1-12 cigarettes a day; 4 = Smoker of 13-25 cigarettes a day; 5 = Smoker of 26 or more cigarettes a day. Net service and accumulated dust exposure were as described by Liddell, McDonald and Thomas (1977, p. 471); dates of start of first job were retained so that gross service could have been calculated to November 1966. Only the year of death (or of loss to view) had been recorded, and cause of death was coded (or recoded) into the Seventh Revision

Table 7.2

CALCULATION OF DUST EXPOSURES

for men in Cohort "A" not included in

Program or process	Input	Output
NEW.1	Bonaventure tape	Discs
WHLIST	Discs from NEW.1	Edit lists
NEW.2	Discs as above	Revised discs & cards
Manual/ Key punch	Cards as above	Revised cards
WHLIST	Cards from above	Edit lists (clear)
UPDTEWH	Cards from above	Revised WH discs
PGM2	WH discs & Dust master	Error print-out
Manual/ Key punch	Error print-out	Work Hist- ory cards

"main mortality cohort"

Comment

373 men with single work histories, and 31 with multiple, separately

404 men as above; 3,181 records

Adjustment to mine codes without alteration of numbers

(a) Removal of errors flagged by WHLIST; (b) Clearance of identity problems

Now 405 men, with 3,080 records

405 men, but redundant records removed, leaving 2,753

17 errors in work histories

17 errors corrected, entered on to punch document; complete revised work histories punched and checked

Table 7.2 (continued)

Program or process	Input	Output	Comment
UPDTEWH	WH disc & amended WH cards	Amended discs	Numerous errors in dust information
Manual/Key punch	List of dust errors	Revised dust cards	Preparation for correction of Dust master file
DUSTCHAD	Revised dust cards	Amended Dust master	Amendment of Dust master file
PGM3	Amended WH & Dust master discs	Exposures by job and year	Preparation for input to FAF; calculation of 7,006 annual concentrations by job
MORTMOD	ID and tracing cards	Mortmod disc	Final preparation for input to FAF
FAF	Mortmod disc	FAFile	Consolidation of exposure data, providing annual exposures for 405 men

BASIC INFORMATION FOR MEN IN COHORT "A"

Columns	Item and "format"	
7-12	Date of birth (day/month/year)	3I2
16-21	Identity number	I6
22-27	Date of test (day/month/year)	3I2
28-31	Height (cms)	F4.1
32-35	Weight (kgs)	F4.1
36-39	FEV _{1.0} (litres)	F4.2
40-43	FVC (litres)	F4.2
44-47	MMF (litres)	F4.2
48-52	Persistent cough, persistent phlegm, breathlessness, wheezing, number of chest illnesses	I5
53-61	Smoking habit, recoded into a single character in column 362	I1
62-66	Clinic, and reference number	A1,I4
67-71	Reading sequence number	I5
72-114	X-ray readings: Reader A	} 43 columns laid out as in p. 4 of the Annex
115-157	B	
158-200	C	
201-243	D	
244-286	E	
287-329	F	
330	Status (Alive, Dead, or Lost to view)	A1
331-336	Date of birth as in "main mortality cohort"	3I2
337-338	Year of death, or loss (blank if alive)	I2
339-341	Cause of death (blank if alive or lost to view)	I3 *
342-345	Date of start of first job (year/month)	2I2
346-349	Recorded end of last job (year/month = 66/11)	2I2
350-353	Net service (years)	F4.2
354-360	Accumulated dust exposure (mpcf.y)	F7.2
361	Mining area (Asbestos or Thetford Mines)	A1

* First digit R or S for accidents at asbestos work

of the International Classification of Diseases.

The x-ray readings had been into the full U/C classification as adopted by the six McGill readers in 1967, i.e. well before its publication in 1970 - see section 3.4 above; however, the detail of which "additional symbols" had been recorded had not been punched, but only the count of the number of "symbols", and similarly there was a record as to whether or not any "comments" had been noted. These last "economies" were introduced in the preparation of the tape file containing the 42,022 readings that replaced one which, during the early 1970s, was found to have been incorrectly written on to tape a year or so earlier; the only way of repairing these deficiencies would have been by recourse to the original reading sheets. The readings for each particular reader were allocated a specific field on the complete record on XMAFWF.

Preliminary processing, partly to test the main analytical program, partly to check on the quality of the data, revealed that the recorded environmental history on a precursor of XMAFWF was inconsistent for one man: his last job was given in the detail as in the 1940s, but he had definitely still been in employment at the end of 1966. A search of the original register showed (a) that he was in the "main mortality cohort" and (b) that he had had employment at three companies, and hence three buff cards; no problems of identity had arisen, but his work since 1947, recorded on one of the buff cards, had inadvertently been omitted in the preparation of the work histories for the mortality cohort study. Although it will be necessary to make appropriate amendments on several files relating to that study before any further

analysis is undertaken, it would have been extremely costly to make the corresponding changes for Cohort "A"; further, this man was still living at the end of 1975 and so of less importance from an epidemiological point of view than a man who had died. He was, therefore, excluded from Cohort "A".

Thus, at the final count, this cohort consisted of 988 men. All were traced to the end of 1975, when 858 were still living (86.8 per cent). A total of 130 had died (13.2 per cent), and cause of death had been ascertained for all but two of the deceased. The attrition from the early count of 1,031 men was of twenty in the "main mortality cohort" and 22 others; none of the latter had died by the start of 1976. (It would have required several additional computer runs to determine the status - alive, dead or lost to view - of those two members of the "main mortality cohort" excluded because no film could be traced on the TRIPLF file or the 17 excluded because there was no complete set of six readings.)

7.6 Cohort "B": definition, sources and numbers

At the outset, it seemed that the enumeration of Cohort "B" would be a comparatively simple task involving only the manipulation of files on magnetic tape. Members of the "main mortality cohort" were defined on ASBMORT, whether an x-ray had been assessed was indicated on TRIPLF, which also gave the reading serial number, and the readings themselves were available on BASICX, indexed by that reading number. However, the complications were great, arising mainly because of men for whom there were now, or had ever been thought to be, more than one buff card in the original register of the complete working population

of the industry. The solution of all identity problems had to be confirmed, and additional difficulties arose for several reasons. First, a man's film might be indexed on TRIPLF under any, some or all of (a) the six-digit numbers identifying his various buff cards and (b) the special number, of less than six digits, allocated to all his records at the time TRIPLF was created (1969-70). Secondly, there might be more than one film for such a man, with increasing problems of accurate linkage. Thirdly, two further files created about the same time, i.e. 1969-70, IDCRDF and SAMASF, were brought into use in the expectation that they would aid the elucidation of the various problems of linkage; however, the first was found to be incomplete and to contain some further errors which, although few in number, rendered the file unsuitable for use as planned, while the latter was found to be even more out-of-date than had been anticipated and to contain certain information of which we could make no sense. Finally, the fact that we had failed to find a complete set of six readings for certain men expected to be in Cohort "A" meant that these men were now available for inclusion in Cohort "B", although initially they had been excluded on the grounds of *prima facie* membership of the other cohort.

Had these shortcomings and difficulties been fully appreciated at the start, it would have been possible to specify a simpler system of data processing, which would have been just as reliable. However, by the time the problems were fully manifest, the original plans were well advanced and there appeared nothing to be gained from abandoning them and starting afresh. Several contingency manoeuvres had to be developed, all devised to "fail safe", and so, at the end of the

process, we were certain that although longer and more complicated than it need have been it had been carried out correctly. In other words, no subject had been excluded from consideration unnecessarily, and none included unless there were no reasonable doubt that the x-ray reading was of a film of the person defined.

After the long process of matching and checking, we found a total of 5,425 cases on both ASBMORT and TRIPLF. Of these, 764 had more than one buff card, but only one film had been read for the majority of them. Indeed, there were only 22 persons for whom readings of two films were traced - too few for any study of differences in readings - and the later film was selected, after a careful study to be sure of its identity, in conformity with criterion (1) of section 7.4 above. We expected to exclude all 604 men from Cohort "A" who were also in the "main mortality cohort" but, because he was under different identity numbers in the two sets of data, one remained in Cohort "B", which at this stage comprised 4,822 cases.

The file BASICX contained 42,022 readings of the films for 15,689 persons. Almost all the films (15,570, or a shortfall of 0.8 per cent) had been read at Stage 2 and so were acceptable for Cohort "B", always provided the subject of the film was in the "main mortality cohort". The 4,822 cases as above were linked with the Stage 2 readings and films for all but 32 men were traced and the readings added to the record; the number of subjects now included was 4,790. The shortfall was 0.7 per cent of 4,822, very similar to that in the complete BASICX file; almost certainly, it was due to the films being

considered "unreadable". There seems no reason to believe that their exclusion could have led to bias in answering the questions of section 7.2. For reasons already given, we also excluded the 231 females, leaving a final count of 4,559 men in Cohort "B".

As before, the rather extensive basic file was cut down as far as reasonable to reduce costs of disc storage and of analysis, and the basic details on the working file (XMBFWF) are given in Table 7.4. Definitions of net service and accumulated dust exposure are as in Liddell, McDonald and Thomas (1977, p. 471). Smoking habit was re-coded from the record on the ASBMORT file as follows:- 0 = non-smokers; 1 through 5 indicate various categories of those believed not to be current cigarette smokers; 6 = 1-12 cigarettes a day; 7 = 13-25 cigarettes a day; 8 = 26-65 cigarettes a day; 9 = not known. This last category (9) included those for whom a questionnaire had not been completed and others where interpretation was doubtful; the category was reduced by about twelve per cent by careful scrutiny of the latter group.

X-ray readings were complete in the same sense as for Cohort "A"; see previous section. To maintain "blindness" in study of inter-observer differences, the readers' identity numbers were altered by ranking the readers according to the number of subjects whose films they had assessed. Once the specification for this process had been written, the re-labelling was carried out by Mr. Mario Rodrigues without further reference to the author, and the computer output containing check totals etc. was verified by a means which meant that the

Table 7.4

BASIC INFORMATION FOR MEN IN COHORT "B"

Columns	Item and "format"	
1	Sex (M)	A1
2	Set (Reader)	I1
9-14	Identity number	I6
15-20	Date of birth (day/month/year)	3I2
30-34	Clinic and reference number	A1, I4
35-39	Reading sequence number	I5
40	Status (Alive, Dead, or Lost ot view)	A1
41	Quality of match in tracing	A/N
42-43	Year of death, or loss (blank if alive)	I2
45-47	Cause of death (blank if alive or lost to view)	I3 *
48-51	Date of start of first job (year/month)	2I2
52-55	Date of end of last recorded job (year/month)	2I2
56-59	Net service (years)	F4.2
60-66	Accumulated dust exposure (mpcf.y)	F7.2
67	Mining area (Asbestos or Thetford Mines)	A1
68-110	X-ray reading' 43 columns laid out as in p. 153 of the Annex	
137	Smoking habit, recoded	I1

* First digit R or S for accidents at asbestos work.

author was kept blind * to the identities of the six readers.

The status of the 4,559 men in Cohort "B" at the end of 1975 was as follows:- 2,957 known to be alive (64.9 per cent); 1,543 dead (33.8 per cent); with 59 lost to view (1.3 per cent). This last percentage is considerably less than in the entire "main mortality cohort", where the losses numbered 1,089 among 10,939 males, or 10.0 per cent. Most of these losses were after short service before 1936, the year in which routine radiology was introduced at Asbestos. Of the losses in Cohort "B", three-quarters were in men whose last employment was before 1951. Cause of death was determined for all but 16 cases (1.0 per cent), mainly among earlier deaths. In the entire "main mortality cohort", there were 125 deaths of unknown cause in a total of 4,463 male deaths (2.8 per cent), a difference again accounted for by the considerably higher proportion of deaths in the entire cohort before the 1950s.

It is usual in follow-up studies to accept the tracing, once achieved, as valid, without further investigation. For the main mortality enquiry, a code had been used to indicate the quality of the linkage of records from various sources. Table 7.5 illustrates how well the tracing had been carried out for the 4,500 men in Cohort "B" known to be alive in 1976 or to have died earlier. The code was devised to reflect the greatest amount of disagreement

* The key, still not read by me, was sealed and has been lodged with Professor McDonald, as my supervisor.

Table 7.5

QUALITY OF RECORD LINKAGE

4,500 men in Cohort "B" known to have died or been alive in 1966

X: Surname and at least one forename identical or close match (i.e. phonetically compatible, accepted alternative or French/English equivalent.)

Y: Match of names less good than above, but considered adequate.

Z: Match of names themselves inadequate, but match confirmed by other evidence.

1: Full dates of birth available in all records, and identical.

2: Full dates of birth available in all records, but one day and/or one year out. Full dates of birth available in all records, but day and month interchanged. Worse than above, but year of birth identical or out by one only.

3: Worse than above.

Alive or Dead Work history	Alive Single	Dead Single	Alive Multiple	Dead Multiple	Total
Number of men	2,564	1,315	393	228	4,500

Cumulative percentages

X 1	91.0	57.5	45.3	29.4	74.1
X 1 and X 2	96.8	91.0	79.6	69.3	92.2
X 1 through X 3, Y 1 and Y 2	<u>99.6</u>	<u>98.6</u>	<u>94.4</u>	<u>93.9</u>	<u>98.5</u>
Above and worse	100	100	100	100	100

Table 7.5

QUALITY OF RECORD LINKAGE

4,500 men in Cohort "B" known to have died or been alive in 1966

X: Surname and at least one forename identical or close match (i.e. phonetically compatible, accepted alternative or French/English equivalent.)

Y: Match of names less good than above, but considered adequate.

Z: Match of names themselves inadequate, but match confirmed by other evidence.

1: Full dates of birth available in all records, and identical.

2: Full dates of birth available in all records, but one day and/or one year out. Full dates of birth available in all records, but day and month interchanged. Worse than above, but year of birth identical or out by one only.

3: Worse than above.

Alive or Dead Work history	Alive Single	Dead Single	Alive Multiple	Dead Multiple	Total
Number of men	2,564	1,315	393	228	4,500

Cumulative percentages

X 1	91.0	57.5	45.3	29.4	74.1
X 1 and X 2	96.8	91.0	79.6	69.3	92.2
X 1 through X 3, Y 1 and Y 2	<u>99.6</u>	<u>98.6</u>	<u>94.4</u>	<u>93.9</u>	<u>98.5</u>
Above and worse	100	100	100	100	100

between sources; quality would thus inevitably appear worse the more documents were involved. The minimum was a single buff card and a smoking questionnaire for the living; however, there were many men with more than one buff card, and of course there was also the death certificate for the deceased. The first two lines of percentages reveal the expected trends in the quality of linkage, but they also indicate extremely high standards of matching records. The linkage indicated by the third line would still be generally considered quite acceptable, and the percentages in each column of this line are uniformly high.

7.7 Summary

In order to answer the following questions:-

1. To what extent can radiological changes in those that have been exposed to asbestos dust predict mortality?
2. Are the predictions of mortality from radiological changes improved or modified by other factors?
3. What are the best factors for predicting mortality?

two cohorts of Quebec chrysotile miners and millers were defined.

Cohort "A" comprised 988 men who were at work at the end of 1966 and had been subjected, mainly in 1967 but in some cases in 1968, to a questionnaire on respiratory symptoms and smoking habits and to lung function tests. The latest chest radiograph to November 1966 had been assessed by each of six readers into the U/C classification, later published by Bohlig *et al.* (1970); see the Appendix at the end of Volume 1 of this thesis. Information available about each man is listed in Table 7.3. By the end of 1975, there had been 130 deaths;

no member of the cohort had been lost to view.

Cohort "B" comprised all 4,559 men who (a) were born in the years 1891 through 1920 and had worked in the chrysotile producing industry for at least a month (and so were included in the "main mortality cohort"), (b) had had an x-ray, the latest to 1966, assessed by one of the six readers mentioned in the previous paragraph, and (c) were not in Cohort "A". A list of the information collected about each man is in Table 7.4. By the end of 1975, there had been 1,543 deaths and 59 men had been lost to view.

The leading information about each man is given in parts "A" and "B" of the Annex to this thesis, bound as Volume 2. The reasons for the sequences in which the men are listed are given in section 8.4, below.

Chapter 8

M E T H O D S

8.1 Introduction

Methods of cohort analysis have for long been a matter of controversy, and will probably remain so despite a recent review by the present author and his colleagues (Liddell, McDonald and Thomas, 1977). This review came about because, from the beginning of their studies of mortality in Quebec chrysotile workers, Professor McDonald and his team were aware of imperfections in the methods they were forced to use in the initial analyses. Several improvements were introduced into later reports (McDonald *et al.*, 1973; 1974), one of them being an approach by taking several controls for each case which I had proposed unaware of Miettinen's (1969) suggestion. The selection of controls and the analysis were carried out by Dr. Gail Eyssen (*cf.* Eyssen and Liddell, 1974), but the method was not fully described in the literature at that time because it had not been adequately explored. There were still possibilities of improvement, and a small group of statisticians met at McGill University in June 1974 to discuss them. Many ideas were exchanged, and a full report (Liddell, 1974) was circulated to all concerned; after agreement, a brief summary was published by Liddell (1975b). Nevertheless, there still remained the need for the McGill group to employ the best possible means of analysis on their important data, and although it was now fairly clear how the basic

problems were to be handled it seemed appropriate to have the principles presented to a wide circle of experts for open discussion which would be published.

Now, only a year after the review was presented to the Royal Statistical Society, there have been further developments in analysis, as mentioned in the discussion and reply (Liddell, McDonald and Thomas, 1977, pp. 485-491) and as explained in a paper by one of the authors of the review (Thomas, 1978). This chapter discusses briefly the need for distinguishing modes of reasoning for analysis from what the study design may appear to imply; thereafter, the main methods readily available with either form of logic are outlined, with advantages and disadvantages, and, finally, the methods used to analyse the data from Cohorts "A" and "B" are described.

8.2 Modes of reasoning

The expression "cohort study" is being used increasingly to describe an investigation which takes a population of known characteristics and works forwards to the affected persons in that population; because of the direction of development, such studies have long been termed "prospective", in the epidemiological literature. However, that term has an everyday meaning, involving placing the enquiry in time, which is frequently misleading. Thus, both Cohort "A" and Cohort "B" were not set up until 1977, and much of the work on them has been, in the temporal sense, retrospective. This is not an unusual situation, and a study of the present nature has sometimes been called a "retrospective cohort" study, which denies the traditional, epidemiologic, use of the adjective (see, for example, Taylor and

Knowelden, 1957; McMahon *et al.*, 1960).

Because a cohort study is prospective, in the sense first used above, it can be analysed by an argument that also works forward, i.e. from cause to effect; such an argument has, since 1710, been styled *a priori*, according to the Oxford English Dictionary. The fundamental application to cohort studies such as the present is as follows:- (1) the population is classified into sub-cohorts according to known characteristics (such as normal or abnormal radiological findings; light or heavy dust exposure; non-smokers, light smokers or heavy smokers); (2) the sub-cohorts are followed through an appropriate "study interval"; (3) the numbers of deaths in each sub-cohort are counted; and (4) comparison of sub-cohorts is made in terms of selected measures of mortality. The mode of argument has clearly been from cause (abnormality of x-ray, dust exposure, smoking) to effect (mortality), i.e. *a priori*.

However, this is not the only form of argument that can be used in a cohort study; it remains possible to compare the characteristics of those who have died against those of the survivors. Here the mode of argument is a working backwards from the fact of death (or survival) to the factors which may have led to the differences. It is equally clear that this style of argument is from effect to cause, designated *a posteriori* (also since 1710 according to the OED). There are two rather different applications of this mode of reasoning. In one, each death, as it occurs, is compared with all still surviving; methods of analysis have been put forward by Cox (1972), based on regression models, and developed by others, including for example

Thomas (1978). In large cohort studies, comparisons of this nature are extremely costly, even with efficient programs for fast computers, and so sampling of the survivors is desirable. If a fixed number of survivors, now called "controls", is selected for each death (or "case"), the material is exactly equivalent to that of a "case-control" study. The method of Cox (1972) and its successors can be applied, but they are rather complex; simpler methods are available in many circumstances. The principle of sampling the living was recommended by Liddell, McDonald and Thomas (1977), and endorsed in the discussion.

The case-control design (previously called "retrospective" in the epidemiological sense, but quite possibly carried out prospectively in the everyday sense) has often been criticised because:- (a) it may be subject to severe bias in data collection; (b) it does not provide estimates of risk, but only of relative risk; and (c) in practice the principles by which the controls have been selected have left much to be desired. It is therefore important to appreciate that the use of *a posteriori* reasoning in a cohort study is of a rather different nature; in particular, criticism (a) will normally not apply (Armitage, 1977). On the other hand, there is no denying that the criteria by which controls are selected are just as important here as in other case-control situations.

8.3 Comparative composite cohort analysis

By far the most generally used applications of *a priori* analysis in the study of mortality in a cohort have been based on "comparative composite cohort analysis", the method that Case and Lea (1955) used for investigating the effects of mustard gas poisoning during World

War I. The cohort is divided into a number of sub-cohorts, who are followed over an appropriate "study interval" (see below). The mortality experienced by each sub-cohort is compared with the experience expected for that group on the basis of some "reference population" (see below). Sex-, age-, year-, cause-specific death rates for the reference population are applied to the "man-years in view" accumulated by the sub-cohort, the man-years being found by summation, over all persons in the sub-cohort, of the years between the start of the study interval and the earliest date of: death, last trace for those lost to view, end of study interval or, when the study interval extends beyond the period of follow-up, the end of follow-up of those alive at that time. In theory, this can be done for each one-year square (or one-year triangle) in the relevant diagonal band of the Lexis (1875) diagram, which has age and time as orthogonal axes. However, the practice has been to use five-year squares to reduce the bulk of the computations.

The choice of *study interval* is of importance, particularly to avoid the fallacy, which appears to have been pointed out first by Enterline and Henderson (1973), that long exposure tends to improve life expectancy; in other words, only those who live to a considerable age have the opportunity to acquire long exposure. It is also important that the classification of sub-cohorts be made on the values of the appropriate characteristics at the start of the study interval, or earlier, but never later.

In Cohort "A", all men were known to be alive at the time of physiological testing, and this has been taken as the start of the

study interval. In Cohort "B", where one set of factors of sub-cohort definition comprised the radiological changes, these must have preceded the start of the study interval. However, as the men were also known to be alive at least until the end of their last recorded job, the study interval could not start earlier than that for each man; otherwise, man-years would be accumulating in the denominators of mortality rates while the numerators remained void until the recorded date of last employment. This date has, then, been taken as the start of the study interval for Cohort "B".

The choice of *reference population* is also not without difficulty. The usual selection has been of national mortality, following Case and Lea (1955), or mortality for other major populations, such as all males in the Province of Quebec (e.g. McDonald and Liddell, 1978) or white males in the United States (e.g. Enterline *et al.*, 1972 etc.) However, these may not be relevant to any specific occupational cohort, because of geographic and socio-economic factors, to say nothing of factors of selection into and out of the cohort. Even rates of a more localized nature may fail to overcome the socio-economic difficulties, and there is no reason to believe that they will improve the situation over selection. Some workers, for instance Dr. I. J. Selikoff's group at Mount Sinai School of Medicine, New York (Selikoff *et al.*, 1978), amend the officially coded cause of death whenever they consider this justified by study of the death certificate or by autopsy findings. However, there would appear to be no way in which corresponding changes could be made for any external reference population, so that it is not possible to find appropriate expected numbers of deaths against which to compare the adjusted observed numbers.

Fortunately, these issues are not of great importance if the aim is to make comparisons between sub-cohorts, without trying to obtain absolute risks for each sub-cohort separately. Indeed, for this aim, any reference population will be satisfactory if its mortality experience is not too widely different from that in the cohort under review. Nevertheless, there are often advantages in an internal reference, i.e. comparing sub-cohorts each against the experience of the entire cohort. In particular, the difficulties over selection may be at least reduced, no special data collection is required, and no restrictions get imposed on the study interval by any lack of availability of material for specific years, or causes, for the reference population, while for normally rare conditions that are nevertheless not uncommon in the cohort, e.g. pneumoconiosis in those exposed to dust, the expectations will be more realistic for internal comparisons.

Liddell, McDonald and Thomas (1977) also discussed various ways in which observed and expected deaths could be compared. These workers had hoped that the potential of a flexible program for linear modeling, GLIM (Nelder, 1975), could be explored in the Quebec asbestos mortality study. However, Dr. I. D. Hill, who volunteered to carry out this exploration, has been unable to do more than preliminary analysis. Despite its drawbacks, the use of the simple ratio between observed and expected deaths, which can be seen to be a Standardized Mortality Ratio (SMR), is still widely used if only for its simplicity and universality; it has a further advantage over other ways of relating observations to expectations in the ease with which it can be partitioned in analysis by χ^2 , in the ways described in general by Armitage (1971, p. 362 *et seq.*) and with particular reference to mor-

tality studies by Liddell, McDonald and Thomas (1977).

A major drawback of comparative composite cohort analysis is in the conflicting aims for the definition of sub-cohorts, which have to remain reasonably large if comparisons between them are to be in any way reliable. If there are several factors of interest, and particularly if their interactions may be important, they cannot easily be examined together, in mutually exclusive sub-cohorts, as is theoretically essential. Instead, they have to be examined one at a time, or in pairs, and this leads to unresolvable problems in the disentangling of "effects" when the factors themselves are correlated.

8.4 A posteriori methods of cohort analysis

The approach of comparing each death with all surviving to that time is theoretically possible, but is not feasible in large cohorts; further, it usually requires modification (of the sort described by Thomas, 1977) from the original proposals, which were devised for use in clinical trials, with rather different constraints (Cox, 1972). This section will therefore be concerned with situations in which the living have been sampled. Further, we will consider only purposive sampling, e.g. to find a set of "controls" against which certain "cases" can be compared; the number of controls for each case will be taken as fixed. This is simpler, and so more practical, than when differing numbers of controls are taken for each case, and there seems no need to extend the discussion further, although Thomas (1978) claims that the methods of analysis he has developed cope with all case-control situations.

Two important aspects of a *posteriori* analysis should be mentioned at the outset. First, all comparisons are internal; this has clear advantages, with the corollary that absolute risks cannot be calculated (except when a method such as that of Cox, 1972, is applied to a cohort in which there has been no sampling). However, unless the reference population in a *priori* analysis is truly relevant, such methods are also unable to produce reliable absolute risks. The second aspect is that, in all but the most exceptional circumstances, all cases of interest can be included. Even if some deaths are of unknown cause, the likelihood is that only a trivially few cases will be missed, while the effect on the controls is only that the pool from which they are to be drawn is a little smaller than otherwise.

There is much current argument (see, for example, Miettinen, 1970; McKinlay, 1975; 1977) about the value of matching in the sampling of controls. Sometimes matching is essential for validity, and then it would appear from a seminar sponsored by the *Journal of Chronic Diseases* in April 1978 (Drs. G. E. Eyssen and D. C. Thomas, personal communications) that the matching should be taken into account in the analysis. However, there are strong indications that results are often virtually unaffected by whether or not the analysis is performed treating the data as matched or unmatched. For example, it is difficult to distinguish the results obtained by Dr. Thomas (personal communication) of the two forms of analysis when applied to the lung cancer deaths to the end of 1975 and their controls, as described by McDonald and Liddell (1978). When controls have been matched with cases for disturbing variables (using the nomenclature of Cochran, 1965), no analysis can assess the effects of such variables, although interactions with

the variables of direct interest (which therefore have not been included in the matching) can be evaluated; they can, of course, be evaluated along with the effects of the disturbing variables themselves, if such variables are not matched for. Thus, a strong argument is being developed for reducing matching to that essential for validity.

As in all forms of case-control investigation, the criteria for the selection of controls are vital. In the Quebec mortality studies, the fundamental criteria were that selection would be strictly at random from among men born in the same year as the case and known to have survived at least into the year following that in which the case died.

Although discussion up to this point has been confined to case-control situations, this is no restriction on a *posteriori* argument. The foundation of such methods is some form of discrimination - so far between the characteristics of the dead and those of the living. The same mode of argument can be applied to comparison between any groups of cases, without reference against "controls". An example would be a comparison of exposure factors in smokers and in non-smokers all of whom had died from lung cancer. It would not then be reasonable to match, in the same way as before, for time variables, but rather to see whether one of the important differences between smoking and non-smoking lung cancer cases was, for instance, age at death. Nor need the groups compared be only two in number. Thus it has recently been possible to examine "latent periods" (i.e. the intervals between first exposure and death) in the 245 lung cancer deaths within the Quebec "main mortality cohort", classified *post hoc* according to dust exposure accumulated to age 45; the first results are in Table 2.2.

Exploitation of such methods of reasoning leads to great flexibility in hypothesis formulation.

8.5 Methods for a priori analysis of Cohorts "A" and "B"

Whatever advantages lie with a *posteriori* reasoning, there can be no doubt that the traditional approach to the analysis of a cohort has attractions, although the simplicity frequently claimed for it (for example by Doll, 1964; Fox, 1977) is more apparent than real. It remains important to carry out certain basic analyses using *a priori* reasoning, and for the moment the best approach appears to be the comparative composite cohort analysis of Case and Lea (1955) - with the modification that Case and Lea used probabilities of dying, while most computer programs, such as MYCL (Hill, 1972) or PGMLA, written by Mario Rodrigues, to my specification, for the McGill analyses, use death rates.

For both cohorts, "A" and "B", we have used as reference the mortality of males in the Province of Quebec. Annual mid-year populations and deaths from all causes (i.e. total deaths), both by five-year age groups, have been published by Statistics Canada, and were punched from the latest revisions. The years covered were 1926 through 1974, and the material for the last year was reproduced to provide approximations for 1975. This has been called Quebec Deck 1. Cause-specific information was sought from Statistics Canada, who were able to supply details of every death, either sex, all ages, for the causes we had specified by codes from the Seventh Revision of the International Classification of Diseases, for the years 1951 through 1973. Programs were written (a) to assemble this material for males, in five-year age

groups, annually, for each of the 12 groups of specific causes listed in Table 7.1, and (b) to calculate the numbers of deaths for causes not specified in that table, by subtraction from the data in Quebec Deck 1. The material for 1973 was reproduced twice to provide approximations for 1974 and 1975, and this has been styled Quebec Deck 2.

Quebec Deck 2 was adequate for Cohort "A"; as already explained, the start of the study interval was, for each man, his date of test and this was never earlier than mid-1967. However, for Cohort "B" there were 116 deaths before 1951 and for these cause-specific death rates for Quebec over the period 1926-50 would have been desirable. Attempts had been made to assemble this material, which would of course have been useful in the main mortality studies, but great difficulties had been encountered. Despite the expenditure of much effort and many dollars, a substantial proportion of error was found in what had been punched, and it would have been necessary to spend much further effort if the material were to be made reliable. After discussion with my supervisor, it was decided not to proceed with this work, and so the only Quebec mortality rates available for 1926-50 were for all causes, i.e. Quebec Deck 1.

The data of Cohort "A" are considerably more extensive than those of Cohort "B", but on rather limited numbers. Nevertheless, because they include respiratory function and symptom details, they are of particular interest. It remained desirable to find, if possible, a sub-division of Cohort "B", as closely comparable as possible to Cohort "A", if only to ensure that the exclusion of the latter from those initially available for the former had not led to any unforeseen

biases. A sub-division to resemble Cohort "A" would consist of those still at work in November 1966 who were known to be alive at the end of 1967 - bearing in mind that no detail of the date of death or loss to view was available other than the year in which the event had occurred. The number of men meeting these criteria was 1,732, and it seemed appropriate to divide the remaining 2,827 into two further classes according to date of last job. The obvious choice was to conform with the dates of Quebec Decks 1 and 2: it was found that 1,422 men had left employment before 1951, and they were designated "Era 1"; 1,405 men had left employment some time from the start of 1951 to October 1966, or were still employed at November 1966 but died before the end of 1967, and they were taken to comprise "Era 2". The previously determined group of 1,732, as like as possible to Cohort "A", was termed "Era 3".

For Cohort "A", each man's study interval began at the time of the physiological test in 1967 or 1968. For Cohort "B" as a whole, the intervals started when the men left employment. However, when this cohort was split by Era, and when regard was taken of which Quebec Deck was available for use, the study intervals had to be adjusted as follows:-

<u>Era</u>	<u>Start</u>	<u>End</u>
1 Before 1951	End of last job	End of 1950
After 1950	Start of 1951	End of 1975
2	End of last job	End of 1975
3	Start of 1968	End of 1975

It will be appreciated that the man-years accumulated for the three Eras separately do not sum to those for Cohort "B" in its entirety: the interval from end of job (November 1966) to the end of 1967 for

men in Era 3 has been excluded. Most analyses were carried out Era by Era, but as will be explained later it is inappropriate to present them in this way. The observed and expected numbers of deaths were therefore totalled, over the three Eras, to obtain corresponding values, and SMRs, for the entire Cohort "B". The numbers observed were correct, but the expectations were slightly low. One analysis was repeated on the complete cohort, and this allowed some study of the effects. Man-years from 1951 through 1975 accumulated for the entire cohort were 55,970, compared with 54,021 when the separate figures for the three Eras were added, a shortfall of 3.5 per cent. The corresponding figures for numbers of deaths expected were 990.3 and 965.5, a shortfall of 2.5 per cent; SMRs would of course be overstated by the same amount, i.e. 2.5 per cent. As was to be anticipated, the shortfall in expectations was consistent over each group of causes of death. Further, in the two sub-cohorts which could be compared on both bases, there was no suggestion of differences in the *relative* effects. While it would have been possible to repeat all the *a priori* analyses on the entire Cohort "B", this would have been expensive and could have gained little. It was therefore decided, again in consultation with my supervisor, that this additional work could not be justified.

A rather simplistic form of the first question to be answered (see Chapter 7, above) is: do those whose chest radiographs are assessed as completely normal have lower mortality than others? This has been answered, directly, in both cohorts, by classifying each subject as radiologically "normal" or "less-than-normal". A reading was taken as normal if there were no record of parenchymal change (profusion of small opacities 0/- or 0/0 for both rounded and

irregular; no large opacities), no record of pleural thickening (whether of the walls or affecting the costophrenic angles, the diaphragm or the cardiac border), no record of pleural calcification, and no "additional symbols". There were 302 subjects in Cohort "A" (30.6 per cent) in whom all six readings were normal. In Cohort "B", where there was only a single reading of each film, the criteria of normality were much easier to meet: 67.7 per cent of subjects were "normal". In both cohorts, mortality in the "normals" has been compared with that in the others, i.e. the "less-than-normals". In Cohort "B", the analysis was carried out separately for each reader.

The instructions for the use of the U/C (and later) classifications of radiographs include provision for recording 0/- for "barndoor" normal films, i.e. those whose parenchyma are so exceptionally normal that the reader has no doubt that all other readers would also call them normal (*cf.* Liddell, 1963). Not all film readers make substantial use of this coding and even for those who do it is rare in a working population. However, when it is used, it is most unusual for other abnormality to be recorded, and it is seldom indeed that other readers rate the parenchyma as other than normal. For a few of the "normal" men in Cohort "A", at least one reader had recorded 0/- for both rounded and irregular small opacities. In Cohort "B", the number of subjects recorded as "barndoor" normal differed from reader to reader, as was to have been expected. In both cohorts, these exceptionally normal cases were compared in terms of mortality with the rest of the "normals", by reader separately in Cohort "B".

A closer examination of the first question was possible from five

further analyses, for both cohorts, after sub-division according to a score of:- (1) small opacities, rounded and irregular combined; (2) large opacities; (3) pleural changes, other than calcification; (4) pleural calcification; and (5) "additional symbols". These analyses were not independent of those by "normality"; nor were they independent of each other. For each radiographic feature, the subjects were classified afresh and the "less-than-normal" subjects may have appeared on several occasions with positive scores for the various features.

The method of scoring the x-ray readings is given in Table 8.1, the first part summarizing the detail of the second. In Cohort "A", the six scores of each feature, one score per reader, were added together to give a summary score. For small opacities, rounded and irregular combined (SSC in Cohort "A" and SC in Cohort "B"), three classes were distinguished, i.e. "absent", "slight" and "present". Three similar classes of pleural changes (PL) were also distinguished in Cohort "B". All other features were dichotomized into "absent" and "present".

In preliminary attempts to answer the second question, about whether radiographic or other factors are important in predicting mortality, three further analyses were also carried out for each cohort, again without regard for independence. The factors were:- (1) mining area (two sub-cohorts in each case: Asbestos and Thetford Mines); (2) accumulated dust exposure (four sub-cohorts in each case); and (3) cigarette smoking (two sub-divisions of Cohort "A", with a third, "unknown smoking habit", in Cohort "B").

Table 8.1

TRANSLATIONS OF X-RAY READINGS

Part 1: Summary

PARENCHYMAL CHANGES

Small opacities: rounded	(profusion) x (# zones)
irregular	(profusion) x (# zones)
combined	SC
Large opacities	LO

PLEURAL CHANGES

Pleural thickening	PT = "Extent" x Grade
Costophrenic angle(s)	CP
Irregular diaphragm	ID
Irregular border	IBG
Pleural, other, "total"	PO
Pleural changes, other than calcification	PL
Calcification (grade)	PCG

SYMBOLS

SY

Small rounded opacities:	profusion	Scale AR *
	zones affected	Count (BR)
Small irregular opacities:	profusion	Scale AI *
	zones affected	Count (BI)
Large opacities		Scale LO †
Costophrenic angle		Scale D1 §
Pleural thickening:	diffuse	Scale D2 §
	plaque	Scale D3 §
	grade	0, 1, 2, 3 (PTG)
Irregular diaphragm		Scale D4 §
Irregular cardiac border		0, 1, 2, 3 (IBG)
Pleural calcification:	grade	0, 1, 2, 3 (PCG)
"Additional Symbols"		Count (SY)

* Scales AR and AI: Notional scale of Liddell and May,
(1966, p. 9) except 0/- → 0

† Scale LO: (Well-defined) A → 1, B → 2, C → 3.
(Poorly defined) D → 1, E → 2, F → 3.

§ Scales D1 through D4: L → 1, R → 1, B → 2.

Part 2.2: Detail (SCORING)

Small opacities	$SC = (AR \times BR) + (AI \times BI)$
Large opacities	LO
Pleural changes, other than calcification	$PL = D1 + (D2 + D3)(PTG) + D4 + IBG$
Pleural calcification	PCG
"Additional Symbols"	SY

In Cohort "A" only, a further eight analyses were possible; these were again based on subdivision of the cohort for one factor at a time, not in combination. For each of persistent cough, persistent phlegm and wheezing, the classification was into those in whom the symptom was absent or present; the same subject may well have appeared more than once as showing symptoms. For breathlessness, the breakdown was into three grades: absent, slight and more definite, corresponding to the codes 0, 1 and 2 + 3, recorded on tape.

Three lung function measurements were considered, *viz:-* FVC, the $FEV_{1.0}/FVC$ ratio and MMF. In each case, we calculated deviations from the regression line relating the measure to height and age, and negative deviations greater in absolute value than one standard deviation of the scatter about the regression line were treated as "impaired". Adiposity was assessed in terms of $(weight)/(height)^2$, i.e. Quetelet's index (Billiewicz *et al.*, 1962), and a subject was considered overweight if his index was more than one standard deviation greater than the mean.

In all cases, Relative Risks were calculated for all causes (total deaths) and for each specific group of causes, and differences between sub-cohorts were examined by a modification of the usual χ^2 procedure. Where there were only two sub-cohorts for any factor under examination, there was only one degree of freedom for the χ^2 calculation. Otherwise, we partitioned the χ^2 orthogonally to allocate one degree of freedom to each partition in what appeared the most logical way. The procedures are illustrated in Chapters 10 through 12 on actual findings.

8.6 Methods for a *posteriori* analysis of Cohorts "A" and "B"

No detailed planning was possible before most of the results from a *priori* analysis had been obtained. It was then clear that, although the "normals" did indeed have lower SMRs than the "less-than-normals", and although important relationships had been found, one of the most interesting findings was of the failure of radiology *always* to predict mortality even where it might have been expected to. These phenomena required investigation, which involved design of the type discussed in section 8.4. But first, a conventional form of case-control analysis has to be described.

Case-control studies could, in theory, have been carried out in relation to all reported deaths. Certain considerations, however, reduced the cause groups of interest to six, which can best be discussed in three pairs: pneumoconiosis and respiratory cancer; accidents and strokes; respiratory tuberculosis and diseases of the heart. One would certainly expect pneumoconiosis to be detected on x-ray, provided that, after the x-ray had been taken, there had been neither significant progression of the disease, i.e. a late "attack", nor substantial additional exposure to a dust hazard (not necessarily asbestos). There appear to be two carcinogens for lung cancer - asbestos dust and, much the more powerful, cigarette smoking - which may act multiplicatively. There might well be what could be termed "smoking cancers", without undue exposure to asbestos, and these might not be detected on the radiograph; equally, there might be "dust cancers" in non-smokers which, although comparatively rare, would be detected, one might expect, through the pneumoconiotic appearances associated with the dust exposure.

As far as the second pair of causes, accidents and cerebro-vascular diseases, are concerned, the aim of case-control studies would be essentially to "prove a negative" - a thankless task, however important in theory. As for the third pair, both respiratory tuberculosis and deaths from heart disease might be linked in some way with dust exposure. However, tuberculosis, if seen on the x-ray, should certainly have been recorded, probably as an "additional symbol"; it might, of course, have been mis-diagnosed, perhaps as large opacities, or indeed the diagnosis on death certification might be incorrect. There might be cases where death was certified as due to a disease of the heart in which the underlying cause of death was dust-related, but there would certainly be many cases, probably the majority, where death recorded as due to heart disease was in no way related to asbestos exposure, and so could not be detected as pneumoconiotic change on the x-ray.

In the light of these considerations, the case-control studies were confined, after consultation with my supervisor, to pneumoconiosis and lung cancer. Further, largely because of the small numbers of such deaths in Cohort "A", the more formal case-control studies were restricted to Cohort "B".

For the two selected conditions, one control was chosen in respect of each case, 31 of pneumoconiosis and 118 of lung cancer. Ideally, the control would have been born in the same year as the case and have survived him, but ensuring that the control's survival was long enough made it necessary on a few occasions to relax the first of these criteria, but never by more than a year or at most two.

This form of matching is considered essential for the validity of the case-control comparison. Additionally, the control was selected from among men whose radiograph had been assessed by the same reader, but no other form of matching was felt necessary, or even desirable, in the light of recent debate on this issue. Where, as usually, there were several men from amongst whom a control could be selected, the choice was made by the author, by strict use of a process of randomization.

Two of the most important questions left unanswered by the *a priori* analyses were why some cases of dust-related disease which one would have expected to be detected on x-ray were not; and what was seen on the radiograph in the "less-than-normal" who later died. To these ends, we studied the readings of all cases of pneumoconiosis, lung cancer and mesothelioma, in both cohorts, and examined the provenance of those with "normal" and "less-than-normal" films.

The simplest form of analysis was applied in each of the *a posteriori* studies.

8.7 Summary

Traditional methods of cohort analysis have used *a priori* reasoning, i.e. from cause forward to effect, classifying the cohort into sub-cohorts which differ in the factors of prime interest, such as radiological features, and comparing sub-cohorts in terms of their mortality experience. However, the aims for defining sub-cohorts are conflicting: if they are to be large enough that measures of mortality will be reliable, it becomes extremely difficult to maintain

them mutually exclusive, and so the examination of more than one or two factors, and particularly of the interactions between several factors, is virtually impossible. Nevertheless, these methods *appear* simple in concept - and of explanation - and so they have been adopted here, at least for exploratory purposes.

Both cohorts have been divided into sub-cohorts, *one factor at a time*, for each of the following factors: radiological normality or otherwise; presence of several radiographic features; mining area; dust exposure; and smoking habit. In addition, Cohort "A" has been correspondingly subdivided according as the subjects had symptoms or depressed lung function or were overweight, or not. A two-way breakdown of Cohort "B" was possible by radiological normality and reader.

Methods using *a posteriori* reasoning, from effect back to cause, are much more flexible, even in a cohort, or "prospective", design. Two causes of death, pneumoconiosis and cancer of the chest, have been singled out for detailed study by such methods, which have included more-or-less conventional case-control studies and also examination of the reasons for the apparent "failures" of the radiological system to predict mortality.

The leading data for each man are listed in two parts, one for each cohort, in the Annex of this thesis, which is bound as Volume 2. The order of presentation of the material, which should aid any approach of an *a posteriori* nature, either on the same causes of death but in greater detail or to other causes of death, and the lay-outs, are described in the Annex.

Chapter 9

DESCRIPTION OF THE STUDY COHORTS

9.1 Introduction

In this chapter, the study cohorts are described and compared. The first section deals with Cohort "A", and then Era 3 of Cohort "B" is examined, showing how little like Cohort "A" it turned out to be, despite the method of its selection. The three Eras of Cohort "B" are then compared, before the entire cohort is described, in as nearly as possible the same terms as for Cohort "A". Finally, it is shown that the six groups of men within Cohort "B" whose radiographs were assessed by the different readers were in fact, as was to have been expected from the method of randomization described by Rossiter *et al.* (1972), closely similar in all measured features.

9.2 The men of Cohort "A"

To recapitulate, these workers were the great majority, 97.3 per cent, of the "physiology cross-section", which has been fully described by McDonald, Becklake *et al.* (1972) and Becklake *et al.* (1972). All 988 men were still at work in November 1966, but the sampling had been heavily weighted towards older men, excluding altogether some of the youngest (i.e. less than 21 years old) and utilising small sampling fractions, except for the oldest of those still under 65 in 1966. All

men were interviewed in 1967 (about 85 per cent of them) or 1968, the earliest interview being in April 1967 and the latest in June 1968. As follow-up was from the date of the physiological testing, age at test is an important consideration: ages ranged from 22.1 years to 66.5, with a mean of 49.3 years. All of the 988 men were traced to the end of 1975; 130 had died.

Table 9.1 gives the distribution of the 988 men by age at test, and shows that the proportion coming from Asbestos (30.1 per cent, overall) was similar in all age groups. Net service, to November 1966, was closely associated with age at test, suggesting that the average age of first employment was about the same in each age group. Accumulated dust exposure was also associated with age at test, as were average dust "concentrations"; even after re-adjustment for the length of the working week, there can be no doubt that the older men had been subjected to much higher dust concentrations, on average, than the younger. The proportion of smokers of at least 13 cigarettes a day was largely independent of age, except for those aged 65 or more at the time of test.

Table 9.2, showing the two-way distribution of the 988 men, by net service and accumulated dust exposure, reveals the expected close association of these two factors; it is also compatible with the previously observed relationship between length of exposure and average "concentration".

The prevalence of each feature of radiographic change is shown, by age at test, in Table 9.3. There was, in most cases, a steady

Table 9.1

MINING AREA, SERVICE, EXPOSURE AND SMOKING: COHORT "A"

	A g e a t T e s t					Total
	<35	45-44	45-54	55-64	>65	
Number of men	149	201	243	378	17	988
Percentage from Asbestos	26.8	27.9	30.5	33.6	-	30.1
Net service (years)	5.3	14.8	19.0	28.3	32.0	19.9
Accumulated dust exposure (mpcf.y)	22	128	215	429	687	259
Average dust "concentration" (mpcf)	4.1	8.7	11.3	15.2	21.5	13.0
Percentage smoking at least 13 cigarettes a day	68.5	73.6	66.3	62.7	41.2	66.3

Accumulated dust exposure (mpcf.y)	N e t		
	<1	1, <5	5, <10
<1	5	4	
1, <3	5	54	
3, <6		25	4
6, <10		28	1
10, <30		23	60
30, <100		4	30
100, <300			
300, <600			
600, <1,000			
1,000, <2,000			
2,000 or more			
Total	10	138	95

s e r v i c e (y e a r s)

10, <15	15, <20	20, <30	>30	Total
				9
				59
1				30
4	5			38
33	5	10	8	139
40	73	70	17	234
19	55	101	61	236
1	16	49	51	117
	5	22	47	74
1	3	6	26	36
		5	11	16
99	162	263	221	988

SERVICE AND EXPOSURE: COHORT "A"

Table 9.2

Table 9.3

PREVALENCE OF RADIOGRAPHIC CHANGES: COHORT "A"

(Percentages of readings)

	A g e a t T e s t					Total
	<35	35-44	45-54	55-64	>65	
Number of readings (six per subject)	894	1,206	1,458	2,268	102	5,928
Small opacities: rounded						
0/1 or greater	1.6	2.2	5.1	4.2	5.9	3.7
1/0 or greater	0.4	0.7	2.5	2.0	2.9	1.7
Small opacities: irregular						
0/1 or greater	6.2	11.3	17.8	25.2	34.3	17.8
1/0 or greater	1.7	2.2	8.0	12.5	19.6	7.8
Large opacities: present	-	0.4	0.3	0.8	-	0.5
Costophrenic angle involvement	0.1	3.6	5.8	10.3	5.9	6.2
Pleural thickening						
Grade 1 or greater	0.2	2.2	4.8	7.7	12.7	4.8
Irregular diaphragm: present	0.2	1.2	2.2	4.9	4.9	2.8
Irregular cardiac border	-	0.3	1.0	3.2	3.9	1.6
Pleural calcification	-	0.6	1.6	7.3	16.7	3.6
"Additional symbols"						
At least one recorded	2.5	5.2	4.1	11.2	15.7	7.0

gradient with age, often distorted only by the figure for the oldest group which contained only 17 men. It was to be expected that the older men, who had also had the heavier exposure to asbestos dust, would show more dust-related changes on x-ray than the younger men. The corresponding gradient for "additional symbols", which are largely unrelated to dust exposure, was again not unexpected, as chest diseases are known to be age-related. The small opacities seen were mostly irregular, there were very few large opacities, but substantial proportions of the men had pleural changes of one sort or another. Thus, reading into the earlier ILO, Geneva, 1958, classification, devised mainly for silicosis and coalworkers' pneumoconiosis and excluding pleural changes, would have produced a very much lower prevalence of radiographic abnormality. The first line of Table 9.4 shows how few men, particularly in the older groups, had films assessed as normal by all six readers. The remainder of this table gives the average values of the scores adopted for use in the *a priori* analyses. That the trends revealed here are closely similar to those of Table 9.3 is confirmation that the scoring system was acceptable for the purposes for which it was devised.

Table 9.5 indicates the prevalence of symptoms, age group by age group. The very low overall prevalence both of persistent cough and of persistent phlegm, and the lack of a gradient with age for the former, are not consistent with the data in Table 3 of McDonald, Becklake *et al.* (1972). This indicates clearly that the answers to the relevant questions, as recorded on the tape QUESTF, have been incorrectly interpreted recently. Although these symptoms are included in the analyses, they cannot be considered reliable.

Table 9.4

RADIOGRAPHIC SCORES: COHORT "A"

	A g e a t T e s t					Total
	<35	35-44	45-54	55-64	>65	
"Less-than-normal" (%)	37.6	60.7	70.8	84.7	94.1	69.4
Small opacities (combined)	1.9	3.0	8.4	12.8	20.8	8.2
Pleural changes *	0.0	0.5	1.1	2.1	3.4	1.2
Pleural calcification	-	0.0	0.1	0.6	1.5	0.3
"Additional symbols"	0.2	0.3	0.3	0.8	0.9	0.5

* other than calcification

Table 9.5

RESPIRATORY SYMPTOMS: COHORT "A"

	A g e a t T e s t					
	<35	35-44	45-54	55-64	<u>>65</u>	Total
<u>Prevalence of symptoms (%)</u>						
Persistent cough	8.1	5.5	6.2	6.3	5.9	6.4
Persistent phlegm	2.7	4.5	4.5	7.1	-	5.2
Breathlessness:						
Grade 3	0.7	1.5	4.9	8.5	17.6	5.2
Grades 3 and 2	9.4	12.4	19.3	28.8	35.2	20.3
Grades 3, 2 and 1	32.2	45.3	54.3	68.5	76.5	55.0
Wheezing						
Grade 2	2.0	6.5	12.8	16.4	-	11.0
Grades 2 and 1	24.2	36.3	42.4	45.8	47.1	39.8
<u>Chest illnesses</u>						
Average number of illnesses						
per hundred men	8.7	26.4	29.6	30.7	47.1	26.5

Fortunately, these are the only inconsistencies revealed for either cohort, when compared with published material, after allowance for the differences in selection and presentation. Thus, breathlessness, although in some sense standardized for age by the form of the questions, showed a clear and not unexpected gradient with age, as did the prevalence of wheezing. The average number of chest illnesses reported is given for the sake of completeness; this average also showed a clear gradient with age, a reflection of the increasing incidence of chest illness with ageing.

Mean values of height, weight and adiposity (assessed by Quetelet's index; see Billiewicz *et al.*, 1962), and of lung function measurements, are given in Table 9.6, by age at test. As frequently in a cross-section, the older men were shorter than the younger. Although weight was also negatively associated with age, adiposity varied only slightly with age, tending to be a little higher for the older than for the younger men. The three direct measures of lung function ($FEV_{1.0}$, FVC and MMF) all showed strong age-gradients, but the effects of differences in height between the age groups has not at this stage been allowed for. The ratio $FEV_{1.0}/FVC$ tended to be slightly less in older men than in younger.

Adiposity and the four measures of lung function were each, separately, related to age at test and height, various combinations of age and height, and weight, by means of standard multiple regression analyses (Armitage, 1971, Chapter 10), using a program in the SPSS package (Nie *et al.*, 1970). Table 9.7 gives the coefficients of regression of each variable on age at test and height (units in Table),

Table 9.6

HEIGHT, WEIGHT AND LUNG FUNCTION: COHORT "A"

		A g e a t T e s t					
		<35	35-44	45-54	55-64	>65	Total
<u>Anthropometry</u>							
Mean height	(m)	1.72	1.70	1.68	1.66	1.64	1.68
Mean weight	(kg)	73.4	73.0	73.4	71.5	67.8	72.5
Adiposity	(1,000)W/H ²	2.48	2.54	2.58	2.59	2.52	2.56
<u>Lung function</u>							
FEV _{1.0}	(1)	3.93	3.45	2.94	2.45	2.08	2.99
FVC	(1)	4.75	4.25	3.76	3.20	2.74	3.78
MMF	(1)	4.32	3.75	2.93	2.34	1.92	3.06
Ratio: FEV _{1.0} /FVC		.830	.814	.781	.764	.766	.788

Table 9.7

LUNG FUNCTION AND ADIPOSITY RELATED TO AGE AND HEIGHT

(Cohort "A")

"Dependent" variable	R e g r e s s i o n c o e f f i c i e n t s			S t a n d a r d e r r o r	
	of age at test (years $\times 10^2$)	of height (m)	constant term	after regression	before regression
FEV _{1.0}	- 4.0370	3.9582	- 1.6780	0.4976	0.7898
FVC	- 3.9676	5.4212	- 3.3868	0.5489	0.8688
MMF	- 5.8869	3.1807	0.6129	1.0323	1.2999
FEV _{1.0} /FVC	- 0.2209	-	0.8974	0.0806	0.0847
(1,000)W/H ²	-	-	2.5597	-	0.3701

together with the constant term in the regression equation, and the standard errors before and after regression analysis.

As had been hoped, and expected from the findings of Billiewicz *et al.* (1962), adiposity was virtually independent of height. It was also only slightly related to age at test; although the F-statistic was 8.09 (degrees of freedom 1 and 985) and so of enormous "statistical significance", the partial correlation coefficient was only 0.0903. Even after all age and height adjustments, the standard error was reduced only trivially, i.e. from 0.3701 to 0.3687. Both $FEV_{1.0}$ and FVC were clearly related to age at test and height, but to no other combinations of these variables, nor to weight. The multiple correlation coefficients were 0.7771 and 0.7757, respectively, with F-statistics of 750.6 and 744.0. The standard errors were considerably reduced by the fitting of the appropriate equation. Preliminary discussion with Professor Becklake had suggested that there might have been some errors in the recording of MMF, and slight confirmation appeared in the rather lower multiple correlation coefficient and F-statistic, compared with those above, i.e. 0.6089 and 290.1. However, these may do no more than reflect the greater inherent errors in the MMF test compared with that on which both FEV and FVC are based. In any case, the analysis confirmed that only age at test and height needed to be taken into account, and that there was considerable reduction in the standard error by doing so. The ratio $FEV_{1.0}/FVC$ was virtually unrelated to height, as might have been expected from the close relationship with height of both numerator and denominator of the ratio. Adjustment for age appears justified, but could reduce the standard error only slightly, while

the coefficient of multiple correlation and F-statistic were only 0.3096 and 104.4, respectively.

A simple demonstration of the extent to which certain of the various factors were interrelated is given in the correlation matrix of Table 9.8. No great reliance should be put on the values of the actual coefficients, particularly as "statistical significance", at the five per cent level of tradition, is associated with a coefficient as low as 0.062. Most of the larger coefficients in this matrix, i.e. those greater than about 0.25 in absolute value, simply reflect phenomena already discussed. Thus, there were substantial correlations between all the radiographic scores (variables 1 through 4), and between them and:- age at test (variable 8), dyspnoea (variable 9), dust exposure (variable 6) and lowered FVC (variable 10, negative values). Dust exposure (variable 6) was directly related to age at test (variable 8) and to dyspnoea and depressed FVC (variables 9 and 10), whereas these last two were not closely correlated. Not shown, but not unexpected, were associations between certain measures of lung function; by far the largest (.80) was that between deviations from the regression predictions of MMF and the $FEV_{1.0}/FVC$ ratio.

Finally, Table 9.9 shows the distribution by cause of the 130 deaths observed in Cohort "A", against expectations based on Quebec Deck 2. Also given in this table are the values of the χ^2 statistics obtained from the Observed and Expected numbers of deaths as $(O - E)^2/E$. These values were high, indicating considerable excesses, for pneumoconiosis and lung cancer; there was also a slight excess of deaths from laryngeal cancer.

Table 9.8

MATRIX OF CORRELATIONS: COHORT "A"

		Variable number									
		1	2	3	4	5	6	7	8	9	10
<u>Radiographic scores</u>											
"Abnormality"	1	*	.51	.31	.34	.05	.24	.00	.37	.13	-.09
Small opacities	2		.	.35	.19	-.01	.25	.03	.32	.23	-.17
Pleural changes *	3			.	.19	.05	.18	-.00	.28	.18	-.18
"Symbols"	4				.	-.01	.10	-.09	.22	.13	-.11
<u>Environmental factors</u>											
Mining area †	5					.	.04	.03	-.05	-.12	-.04
Dust exposure §	6						.	.04	.49	.23	-.21
<u>Social factors</u>											
Smoking	7							.	-.03	.11	-.03
Age at test	8								.	.28	.
<u>Symptomatology</u>											
Dyspnoea	9									.	-.19
FVC ¶	10										.

* other than calcification

† a positive sign means higher value of correlate
at Thetford Mines

§ square root of accumulated dust exposure

¶ deviation from regression "prediction"

Table 9.9

DEATHS IN COHORT "A"

From date of test to the end of 1975

(O = Observed deaths; E = Deaths expected from Quebec Deck 2; SMR = O/E)

$$\chi^2 = (O - E)^2 / E$$

	O	E	SMR	χ^2
Pneumoconiosis	3	0.14	21.48	58.43
Cancer of the chest	22	10.61	2.07	12.23
Respiratory tuberculosis	0	1.00	0	1.00
Other respiratory conditions	6	7.71	.78	0.38
Diseases of the heart	44	52.36	.84	1.33
Cancer of oesophagus or stomach	5	3.88	1.29	0.32
Cancer of colon or rectum	3	4.26	.71	0.37
Other abdominal cancers	5	3.17	1.58	1.06
Cancer of larynx	2	0.70	2.87	2.41
Other malignant diseases	11	9.49	1.16	0.24
Cerebro-vascular diseases	5	8.64	.58	1.53
Accidents	6	8.96	.67	0.98
Other known causes	16	18.05	.84	0.23
Cause not known	2	-	-	-
ALL CAUSES	130	128.95	1.01	0.01

9.3 Era 3 of Cohort "B"

It will be recalled that this subdivision of Cohort "B" was made with a view to comparisons with Cohort "A". Here are the percentage age distributions of the two groups:-

	Cohort "A"	Era 3 of Cohort "B"
	(Age at test)	(Age at Nov. 66)
Less than 35	15.08	-
35 - 44	20.34	-
45 - 54	24.60	69.69
55 - 64	38.26	27.31
65 and over	1.72	3.00
	<u>100</u>	<u>100</u>

The mean age at test in Cohort "A" was 49.3 years and at November 1966 in Cohort "B" was 52.9 years; adjustments to the start of the study interval in that cohort increased the difference between the mean ages to 4.7 years. Further, and perhaps more important, because there was a substantial proportion of the men in Cohort "A" who were born after 1920 but none, by definition, in Cohort "B", the *shapes* of the distributions are quite different. In addition, net service to November 1966 was 24.8 years in Era 3 compared with 19.9 years in Cohort "A", and dust exposure accumulated to November 1966 was 333 mpcf.y against 259, although this is a reflection of the length of employment difference rather than of differences in dust concentrations.

Although smoking habits had been assessed on rather different bases, there did not appear to be great dissimilarity between the two groups, and, after due allowance had been made for the number of

readers, the scores of radiological change tended to be a little higher in Era 3, no doubt because of the higher average exposure to asbestos. Finally, Table 9.10 gives the distribution by cause of the 241 deaths in Era 3, in the same layout as for the previous table, and shows a tiny shortfall of total deaths, and marked excess only for deaths due to pneumoconiosis.

Despite some of the similarities of these two groups of men, the differences in age distributions and in exposure are considered large enough to render further comparisons between them unrewarding.

9.4 The three Eras of Cohort "B"

Some important differences between the three Eras of Cohort "B" are illustrated in Table 9.11. The confounding of the restriction on dates of birth, to the years 1891 through 1920, and the definitions of the eras in terms of dates of last employment in the industry, meant that Era 1 was much the youngest of the three at the start of their study intervals, and Era 3 much the oldest, while the average length of study interval was much greater in Era 1 than for the others. Although there were only comparatively small differences between the Eras in their distributions by dates of birth, tracing problems had been much worse for men in Era 1. Another important difference arose from the much earlier start of routine chest radiography at Asbestos than at Thetford Mines; this led to a very much higher proportion of men from this town in Era 1 than in the other Eras, when the proportion reflects much more accurately the numbers employed in the two mining areas. One reason for the comparatively low rate of tracing in Era 1 was the short net service; many men would have had employment of very

Table 9.10

DEATHS IN COHORT "B", Era 3

1968-75

(O = Observed deaths; E = Deaths expected from Quebec Deck 2; SMR = O/E)

$$\chi^2 = (O - E)^2/E$$

	O	E	SMR	χ^2
Pneumoconiosis	11	0.25	43.65	462.25
Cancer of the chest	27	21.72	1.24	1.28
Respiratory tuberculosis	0	1.84	0	1.84
Other respiratory conditions	13	14.07	.92	0.08
Diseases of the heart	97	104.43	.93	0.53
Cancer of oesophagus or stomach	7	7.47	.94	0.03
Cancer of colon or rectum	4	8.03	.50	2.02
Other abdominal cancers	6	6.58	.91	0.05
Cancer of larynx	1	1.45	.69	0.14
Other malignant diseases	19	17.90	1.06	0.07
Cerebro-vascular diseases	11	15.40	.71	1.26
Accidents	16	15.51	1.03	0.02
Other known causes	26	34.78	.75	2.22
Cause not known	3	-	-	-
ALL CAUSES	241	249.42	.97	0.28

Table 9.11

DIFFERENCES BETWEEN ERAS IN COHORT "B"

	Era 1	Era 2	Era 3
Number of men	1,422	1,405	1,732
Distribution of man-years by age	%	%	%
Less than 45	40.8	13.6	-
45-64	52.9	56.0	89.0
65 and over	6.4	30.4	11.0
	<hr/> 100	<hr/> 100	<hr/> 100
Man-years accumulated per man	25.0	9.7	7.6
Average age on survival to the end of 1975 (years)	65.5	69.6	62.0
Lost to view (per cent of total)	3.1	1.1	-
Smoking histories not available (per cent of total)	11.9	2.8	0.9
Percentage of men from Asbestos	78.3	45.8	38.3
Net service (years)	6.4	21.8	24.8
Accumulated dust exposure (mpcf.y)	156	459	333
Average dust "concentration" (mpcf)	24	21	13

short duration only, and such persons are notoriously difficult to trace. Accumulated dust exposures in the three Eras represent the resultant of differences both in net service and in dust concentrations.

One other difference is even more dramatic: because all deaths in 1966 and 1967 had been excluded from Era 3, in the attempt to make it similar to Cohort "A", the proportional mortality was affected, as it was also by secular trends, particularly in the almost complete eradication of respiratory tuberculosis, and the growing incidence of lung cancer; some of the larger differences between Eras are illustrated below:-

	Era 1	Era 2	Era 3
Number of deaths (all causes)	532	770	241
Percentage due to:-			
Pneumoconiosis	0.4	2.3	4.6
Cancer of the chest	5.5	8.4	11.2
Respiratory tuberculosis	7.1	2.7	-
Other respiratory	4.1	5.1	5.4
Cerebro-vascular diseases	4.5	8.7	4.6
Accidents	13.7	7.5	6.6
Other causes	64.6	65.2	67.6
	<u>100</u>	<u>100</u>	<u>100</u>

As noted in section 8.5, the *a priori* analyses were, for the most part, carried out on each Era separately, but the findings reported below are for the complete cohort. No important differences between Eras were noted.

9.5 The men of Cohort "B"

To recapitulate, men were included in Cohort "B" if (a) they were born in the years 1891 through 1920 and had worked for at least

a month in the Quebec chrysotile producing industry, i.e. were in the "main mortality cohort", and (b) a radiograph taken during employment had been collected in 1967 and read at Stage 2 (as described by Rossiter *et al.*, 1972) by one of six readers, into the forerunner of the U/C classification (Bohlig *et al.*, 1970). The study interval for each man started at the end of his last recorded employment in the industry, and so "age at last job" is an important consideration: ages ranged from 15.1 years to 74.0 years, with a mean of 47.2 years. All but 59 were traced to the end of 1975; there had been 1,543 deaths.

Table 9.12 corresponds to Table 9.1, except that the distribution of men is by age at last job, as distinct from age at test, but for both tables age has been calculated from the start of the study interval. The proportion from Asbestos varied with age, because of the interaction between this factor and the earlier start of radiology in that area. As in Cohort "A", net service and accumulated dust exposure showed the expected trends. The average dust "concentration", however, is less easy to interpret, because of further interactions with time and place. The smoking percentage in this cohort was dependent on age at last job, perhaps reflecting habits varying with era of birth.

The two-way distributions, by net service and accumulated dust exposure, are shown for the two mining areas in Table 9.13. The diagonal patterns in both sections of this table are similar to that in Table 9.2. The differences between Asbestos and Thetford Mines are, of course, complicated by the varying proportions from the two areas by era of employment, bearing in mind that dust concentrations were

Table 9.12

MINING AREA, SERVICE, EXPOSURE AND SMOKING: COHORT "B"

	A g e a t L a s t J o b					
	<35	35-44	45-54	55-64	>65	Total
Number of men	901	738	1,702	878	340	4,559
Percentage from Asbestos	80.8	67.9	41.2	45.2	27.1	53.1
Net service (years)	4.2	8.4	21.3	28.6	34.0	18.2
Accumulated dust exposure (mpcf.y)	104	162	320	506	709	317
Average dust "concentration" (mpcf)	25	19	15	18	21	17
Percentage smoking cigarettes	67.9	63.5	65.1	54.3	40.7	61.3

Accumulated dust exposure (mpcf.y)	N e t		
	<1	1, <5	5, <10
<1	137	7	
1, <3	109	30	1
3, <6	37	83	15
6, <10	21	74	7
10, <30	24	105	109
30, <100	5	87	65
100, <300		29	54
300, <600			33
600, <1,000			1
1,000, <2,000			
2,000 or more			
Total	333	415	285

Table 9.13 (A)

SERVICE AND EXPOSURE: COHORT "B" (ASBESTOS)

service (years)				
10, <15	15, <20	20, <30	>30	Total
				144
				140
2				137
8	8			118
43	16	10	8	315
59	154	178	62	610
42	48	161	99	433
53	25	103	83	297
15	23	48	82	169
	8	12	35	55
		1	1	2
222	282	513	370	2,420

Accumulated dust exposure (mpcf.y)	N e t		
	<1	1, <5	5, <10
<1	31	8	
1, <3	33	27	3
3, <6	15	13	6
6, <10	8	23	3
10, <30	16	67	52
30, <100	7	48	42
100, <300	1	17	36
300, <600		3	14
600, <1,000		3	3
1,000, <2,000			5
2,000 or more			
Total	111	209	164

Table 9.13 (TM)

SERVICE AND EXPOSURE: COHORT "B" (THETFORD MINES)

service (years)				
10, <15	15, <20	20, <30	>30	Total
				39
				63
5				39
3	3			40
31	7	12	17	202
70	67	95	35	364
62	72	212	144	544
22	50	148	110	347
6	12	124	87	235
6	8	63	97	179
1	4	18	64	87
206	223	672	554	2,139

substantially lower at Asbestos than at Thetford Mines, but in both areas decreased greatly over the years.

The prevalence of each radiographic feature is given in Table 9.14 (*cf.* Table 9.3). Fairly similar trends with age can be discerned, as well as a broadly similar pattern of the sorts of abnormality observed. Because there was only one reader of each film, the proportion of "less-than-normals" was much lower in Cohort "B" than in Cohort "A"; however, over half the men aged 65 or more at the time of last job (shortly after the x-ray in most cases) were assessed as "less-than-normal" - see Table 9.15 (*cf.* Table 9.4) which again reveals trends similar to those in the previous table, and confirms the utility of the scoring system.

The correlation matrix in Table 9.16 is of rather smaller dimensions than those for Cohort "A" (Table 9.8); it revealed bigger differences between mining areas than in the other cohort, particularly in dust exposure, but neither this nor any other association was unexpected.

Table 9.17 gives the numbers of deaths observed since 1950 against expectations based on Quebec Deck 2, and adds SMR and χ^2 as before. There was a large excess of deaths from all causes; in addition to the clearly significant excesses from pneumoconiosis and lung cancer, which were to have been expected, there were major excesses of deaths due to many other causes. This experience, rather different from that in the "main mortality cohort" of 10,939 men (McDonald *et al.*, 1979) from which Cohort "B" was drawn, requires explanation. Net service

Table 9.14

PREVALENCE OF RADIOGRAPHIC CHANGES: COHORT "B"

(Percentages of readings)

	A g e a t L a s t J o b					Total
	<35	35-44	45-54	55-64	>65	
Number of readings (one per subject)	901	738	1,702	878	340	4,559
Small opacities: rounded						
0/1 or greater	1.1	1.2	2.3	4.7	5.6	2.6
1/0 or greater	0.8	0.8	1.3	3.3	5.0	1.8
Small opacities: irregular						
0/1 or greater	4.1	9.3	16.9	27.1	30.6	16.1
1/0 or greater	1.4	5.1	7.1	15.9	22.4	8.5
Large opacities: present	1.2	0.4	1.5	2.7	3.2	1.6
Costophrenic angle involvement	4.3	2.6	8.6	11.8	17.9	8.1
Pleural thickening						
Grade 1 or greater	2.2	1.8	6.0	10.3	17.9	6.3
Irregular diaphragm: present	1.0	1.4	3.8	7.3	9.4	3.9
Irregular cardiac border	0.3	0.5	2.2	5.0	8.5	2.6
Pleural calcification	1.6	1.5	3.8	6.6	12.4	4.2
"Additional symbols"						
At least one recorded	6.1	5.6	8.1	13.1	22.6	9.3

Table 9.15

RADIOGRAPHIC SCORES: COHORT "B"

	A g e a t L a s t J o b					Total
	<35	35-44	45-54	55-64	>65	
"Less-than-normal" (%)	14.5	18.6	34.4	47.6	59.1	32.3
Small opacities (combined)	0.4	0.8	1.3	3.3	3.7	1.6
Pleural changes *	0.1	0.1	0.3	0.5	0.9	0.3
Pleural calcification	0.0	0.0	0.1	0.1	0.2	0.1
"Additional symbols"	0.1	0.1	0.1	0.2	0.2	0.1

* other than calcification

		Variable number						
		1	2	3	4	5	6	7
<u>Radiographic scores</u>								
"Abnormality"	1	.	.58	.54	.46	.24	.23	.02
Small opacities	2		.	.37	.16	.16	.20	-.01
Pleural changes *	3			.	.16	.19	.18	.01
"Symbols"	4				.	.07	.09	-.03
<u>Environmental factors</u>								
Mining area †	5					.	.26	.04
Dust exposure §	6						.	-.02
<u>Social factor</u>								
Smoking	7							.

* other than calcification

† a positive sign means higher value of correlate
at Thetford Mines

§ square root of accumulated dust exposure

Table 9.16
MATRIX OF CORRELATIONS: COHORT "B"

Table 9.17

DEATHS IN COHORT "B"

1951-75

(O = Observed deaths; E = Deaths expected from Quebec Deck 2; SMR = O/E)

$$\chi^2 = (O - E)^2 / E$$

	O	E	SMR	χ^2
Pneumoconiosis	31	0.91	34.07	994.95
Cancer of the chest	119	67.16	1.77	40.01
Respiratory tuberculosis	40	11.85	3.38	66.87
Other respiratory conditions	67	52.89	1.27	3.76
Diseases of the heart	566	415.93	1.36	54.15
Cancer of oesophagus or stomach	53	31.10	1.70	15.42
Cancer of colon or rectum	28	32.35	.87	0.58
Other abdominal cancers	21	23.19	.91	0.21
Cancer of larynx	4	5.02	.80	0.21
Other malignant diseases	93	71.60	1.30	6.40
Cerebro-vascular diseases	101	70.02	1.44	13.71
Accidents	110	61.36	1.79	38.56
Other known causes	183	146.92	1.25	8.86
Cause not known	11	-	-	-
ALL CAUSES	1,427	990.28	1.44	192.60

in Cohort "B" was 18.2 years compared with only 10.5 years in the complete cohort, and accumulated dust exposure was 317 mpcf.y compared with 202 mpcf.y. However, these are not the major reasons for the high excess mortality in Cohort "B"; rather the explanation lies in death at work or which followed retirement on grounds of ill-health. Except for Era 3, either of these events would have led to the inclusion of the man concerned in the study group. Indeed, in the whole of Cohort "B", a high proportion of deaths (27.9 per cent) occurred before the end of the year following that in which employment terminated; any such deaths among men still employed in November 1966 would move them from Era 3 to Era 2 and helps to account for an extremely high proportion of such deaths, 46.2 per cent, in Era 2. It is possible to infer from a statement on p. 472 of Liddell, McDonald and Thomas (1977) that in the entire "main mortality cohort", less than about a fifth of deaths to the end of 1975 occurred within twenty years of first employment, a startling contrast when it is borne in mind that the average period of employment in Cohort "B" was less than twenty years.

Although so many early deaths in Cohort "B" might suggest a denial of the so-called "healthy worker effect" (see for example Fox and Collier, 1977), evaluation would require a rather different analysis, in which all men in the cohort at work at a given time be followed from that point. However, what is clear is that Cohort "B" would not have been suitable for an investigation of mortality in relation to environmental factors. On the other hand, it in no way detracts from the data for the present purposes; indeed, the comparatively large number of early deaths allows the possibility of examining whether or not they could be predicted from a radiograph taken only a fairly

short time before death.

9.6 Randomization of men in Cohort "B" to film readers

The method by which the films for all 15,689 subjects were placed into thirty batches, five of which were to be assessed by each reader, was described by Rossiter *et al.* (1972); it was one of shuffling by dealing, common among card players as one of the best modes of randomization. In practice, even on the enormous numbers of large films, it seems to have worked extremely well. The 4,559 men in Cohort "B" had been classified by reader into what will be called "sets" varying in size from 727 to 787, against the average of 760; there is no trace of inequality in this allocation, particularly when it is recalled that one reason for differing sizes would be the proportion of films considered "unreadable", a proportion determined by the subjective judgement of the individual reader.

The total number of men lost to view was 59, distributed between sets as follows:- 5, 7, 9, 9, 14, 15. Again, there is no suggestion of factors other than chance at work. Of those traced, 34.3 per cent had died: the proportion varied between sets from 32.5 per cent to 36.4 per cent, again without any trace of other than chance effects: a test of the equality of proportions yielded $\chi^2 = 4.57$ with five degrees of freedom, a value that would be at least equalled in more than 60 per cent of allocations. Examination of the differences between sets in the numbers of deaths by specific groups of causes suggested once more that all differences could be accounted for by the effects of randomization. Similarly, the six distributions of subjects by quinquennium of birth, within set, were tested for equality; here the χ^2

statistic has 25 degrees of freedom and was calculated as 30.47, with associated P-value of a little less than 20 per cent.

Finally, three other variables were examined:- age at last job; net service; and accumulated dust exposure. A one-way analysis of variance was carried out on each to test the hypothesis that the means were equal in the six sets. This led in each case to an F-statistic with 5 and 4,553 degrees of freedom; the values of F were 1.08, 1.45 and 0.54, respectively, all without trace of statistical significance - on the null hypothesis, the median value of F would be close to 4.4, and statistical significance at the traditional five per cent level would require F as large as 11.1.

It would therefore seem that the randomization achieved its purpose in equalizing the sets, and hence that differences that did exist between the six sets of subjects in terms of radiographic assessment or relations of such assessments to mortality or other factors were almost certainly due to differences between the readers. In fact, the percentage assessed "less-than-normal" by each reader is given, by age at last job, in Table 9.18. Although, within reader, a gradient with age is obvious, its severity depended on the reader: the prevalence of "less-than-normals" in those 65 and over, expressed as a ratio against the corresponding prevalence in those less than 35 on last employment, varied from 67.7 / 18.5 or 3.66:1, for Reader 6, to 60.0 / 11.3 or 5.31:1, for Reader 3. More important is the very large difference between readers in their assessments of overall prevalence of abnormality, varying from 20.9 per cent (Reader 1) to 39.9 per cent

Table 9.18

RADIOGRAPHIC ABNORMALITY, BY READER

(Percentages of readings assessed as "Less-than-normal")

	A g e a t L a s t J o b					Total
	<35	35-44	45-54	55-64	≥65	
Reader 1	11.1	11.2	19.9	32.8	45.6	20.9
Reader 2	11.5	11.4	24.4	33.1	47.2	23.8
Reader 3	11.3	14.7	43.1	60.9	60.0	37.1
Reader 4	16.5	28.8	44.1	54.4	70.6	39.9
Reader 5	17.4	24.8	37.2	46.8	67.9	35.0
Reader 6	18.5	20.9	37.2	53.1	67.7	36.2
ALL READERS	14.5	18.6	34.4	47.6	59.1	32.3

(Reader 4). These differences are of undoubted significance: χ^2 was calculated as 105.85, with five degrees of freedom, and the P-value is extremely low.

9.7 Summary

Although the 988 men in Cohort "A" were considerably older than the population at work in November 1966, the period of follow-up was short - no more than seven-and-a-half years - and only 130 had died by the end of 1975, almost exactly the number expected on the basis of Quebec male mortality. However, there were excesses due to diseases known to be asbestos-related, i.e. pneumoconiosis and cancer of the chest; excluding these causes, there were 105 deaths compared with 118.20 expected, giving a Standardized Mortality Ratio of 0.89. As was to have been anticipated, both from first principles and from previous publications, the older men in this cohort had had longer service, at heavier dust concentrations, than the younger. The older men were a little shorter, but of similar adiposity, and they had fairly similar smoking habits; they reported more respiratory symptoms, and exhibited more signs of pulmonary abnormality, both radiological and physiological. Errors in data processing meant that the symptoms listed as persistent cough and persistent phlegm were not reliably transcribed; it is possible they refer to particularly severe manifestations of bronchitis.

Cohort "B" did not overlap with Cohort "A", and the 4,559 men in it contained much more than a representative proportion from Asbestos, Quebec, because of the earlier start of routine radiology there. The

method of selection also meant that mortality was high, especially from sudden death, including accidents, myocardial infarction and stroke. There were also large excesses from pneumoconiosis and chest cancer. As in Cohort "A", men who were older when they left employment had had longer service; however, because they might have left at any time in the period from the start of radiology to the end of 1966, there was little variation in average dust concentration with age at leaving. Those older at leaving included a lower proportion of cigarette smokers than the younger. Again as was to be expected, the older showed more radiographic change, both parenchymal and pleural, and of "additional symbols".

Chapter 10

FINDINGS I

10.1 Introduction to Chapters 10 through 13

Chapters 10 through 13 present the findings from both study cohorts. Those from Cohort "A" are given before those for Cohort "B", but even although the radiological assessments were made by six readers the many fewer deaths in Cohort "A" (130 compared with over 1,400) render the findings in this cohort less reliable than those in Cohort "B"; further there are several tables in which it would be impossible or unrewarding to provide results for the smaller cohort.

In Chapter 10, the first concern is with total mortality, i.e. that from "all causes", in relation to whether the radiograph was assessed as "normal" or "less-than-normal", with consideration of differences between readers for Cohort "B". The study is then extended to examine, one after the other:- deaths due to specific groups of causes; various radiographic features; and other factors, environmental, physiological, etc.

Pneumoconiosis, cancer of the chest and mesothelioma are all asbestos-related diseases and should be associated with x-ray change, although the rapid progress of the malignant conditions may make direct association with radiographic change tenuous. These three causes of

death are studied in considerable depth in Chapter 11. Deaths from respiratory tuberculosis and other respiratory conditions, and some deaths recorded as due to heart diseases may also be asbestos-related; they might be manifest on the chest radiograph either directly or perhaps indirectly through the pneumoconiotic changes associated with the dust exposure. Relationships between x-ray changes and deaths from these causes are also described in Chapter 11.

Whether or not deaths from the other groups of causes of Table 7.1 are dust-related, any x-ray changes could surely only be pneumoconiotic and related at best indirectly to the disease process. Deaths from these causes (cancer of oesophagus or stomach; cancer of colon or rectum; other abdominal cancer; cancer of the larynx; other cancers; strokes; accidents; and known causes not already included) form the subject of Chapter 12. A brief summary of findings is in Chapter 13.

In many of the tables, the following headings:- O, E, SMR, RR and χ^2 are used, with the meanings indicated below.

O represents the number of deaths observed, from 1951 or later start of the study interval to the end of 1975.

E represents the number of deaths expected on the basis of mortality in Quebec, 1951-75, i.e. calculated by comparative composite cohort analysis (Case and Lea, 1955) using Quebec Deck 2 as reference; note that estimates have had to be made for the last two years - see section 8.5, above.

SMR is the ratio O/E, which can be shown to be a mortality ratio standardized, by the "indirect method" (*cf.* Liddell, 1960), for both age and year of death.

RR, or Relative Risk, is the ratio of the two SMRs it stands beside.

χ^2 designates a statistic which, asymptotically, has the χ^2 distribution with one degree of freedom. The various methods of calculating this statistic are discussed as each is introduced.

The values of Relative Risk, RR, measure the size of an effect, those of χ^2 give an indication of its "statistical significance". The critical values of the theoretical distribution are as follows (calculated from Diem, 1962):-

Probability	10%	5%	1%	0.1%	0.01%	0.001%
χ^2	2.71	3.84	6.64	10.83	15.14	19.51

There are several reasons why this brief table does not give reliable estimates of the significance of Relative Risks quoted in these chapters. First, many are based on expectations so small that the distribution of the statistic is not close to the asymptotic form. Secondly, the statistics have not been determined independently. Thirdly, many statistics have been calculated for both cohorts, and the problems of simultaneous inference arise (see, for example, Miller, 1966). A fourth difficulty, of interpretation, derives from the fact that the χ^2 statistic, which has the form $(O - E)^2/E$, is of dimension E (or O), in other words depends on the numbers of deaths in the test. This means that the same Relative Risk in Cohort "B" as in Cohort "A" would lead to a value of χ^2 about ten times larger in the cohort with over 1,400 deaths than in that with only 130.

Nevertheless, the χ^2 statistics can be used as a guide to the relative importance of an observed Relative Risk, although no P-value

can be associated with it. With this proviso, and with particular caution, guidance can still be obtained even when expectations are very small. It is important not to make the best (i.e. an accurate probability statement) the enemy of the good (i.e. a less reliable but still revealing approximation). Many statistical texts state that χ^2 statistics should not be calculated in any situation where an expectation falls below some arbitrary value (often 5), although Cochran (1954), among others, has suggested considerably more lenient rules*.

* An illustration of what can be lost by rigid application of a rule of thumb can be found in considering the incidence of mesothelioma in Cohort "B". From the data of McDonald and McDonald (1977), adjusting the proportional mortality of mesothelioma in Canada (i.e. 25 male deaths in 1970 in a total of 82,052 deaths from all causes in men over 24 years of age, or 0.305 per thousand) by a factor of two to allow for the higher ascertainment rate of mesotheliomas in the Province of Quebec, the number of mesotheliomas to have been expected in Cohort "B" may be estimated as $2 \times 0.305 \times 1,427/1,000$ or 0.87, whereas five were observed; the value of $\chi^2 = 19.62$, with associated probability a fraction less than 0.001 per cent. While this P-value is in no sense precise, it does suggest that as many as five mesotheliomas in Cohort "B" did not arise from purely chance factors. In Cohort "A", the corresponding figures are: $O = 1$; $E = 0.08$; $\chi^2 = 10.70$, with probability, from the tables, a little greater than 0.1 per cent. Here, with only one observed death, the finding *by itself* would have to be treated with great caution; nevertheless, in conjunction with that in Cohort "B", it provides convincing evidence of a serious mesothelioma risk.

10.2 Total mortality in men with "less-than-normal" radiographs

Mortality from all causes is summarized for both cohorts in Table 10.1, in relation to whether a subject had been assessed as "normal" or "less-than-normal". The χ^2 statistics have been calculated by multiplying each tabled value of E by a factor (all observed deaths) / (total of expected deaths). In this way, expectations were obtained for the calculations which were, in total, the same as the total of deaths observed, and which then allowed an internal comparison of the two sub-cohorts defined in terms of radiological findings. It can be shown, by simple but tedious algebra, that the statistic can be calculated as

$$\chi^2 = (RR - 1)^2 O_1 O_2 / (RR)(O_1 + O_2)$$

where RR and O have the usual meanings and the suffixes indicate the two groups being compared.

In every case of Table 10.1, the Relative Risk of the "less-than-normals" compared with the "normals" was greater than unity. As indicated by the values of χ^2 , the effect was rather less significant for Cohort "A" than for Era 3 of Cohort "B", although similar in magnitude (RRs of 1.24 and 1.33, respectively), at least in part due to the differences in the numbers of deaths. The effects were undoubtedly large for the other two Eras of Cohort "B" (RRs of 1.59 and 1.72). One reason for these differences may lie in the exclusion of deaths before the end of 1967 from the two groups recently at work and with comparatively low Relative Risks. In the two earlier Eras of Cohort "B", the intervals between x-ray and death were short for substantial proportions of the men, and "prediction" of mortality from radiographic changes may thus have been improved.

10.2 Total mortality in men with "less-than-normal" radiographs

Mortality from all causes is summarized for both cohorts in Table 10.1, in relation to whether a subject had been assessed as "normal" or "less-than-normal". The χ^2 statistics have been calculated by multiplying each tabled value of E by a factor (all observed deaths) / (total of expected deaths). In this way, expectations were obtained for the calculations which were, in total, the same as the total of deaths observed, and which then allowed an internal comparison of the two sub-cohorts defined in terms of radiological findings. It can be shown, by simple but tedious algebra, that the statistic can be calculated as

$$\chi^2 = (RR - 1)^2 O_1 O_2 / (RR)(O_1 + O_2)$$

where RR and O have the usual meanings and the suffixes indicate the two groups being compared.

In every case of Table 10.1, the Relative Risk of the "less-than-normals" compared with the "normals" was greater than unity. As indicated by the values of χ^2 , the effect was rather less significant for Cohort "A" than for Era 3 of Cohort "B", although similar in magnitude (RRs of 1.24 and 1.33, respectively), at least in part due to the differences in the numbers of deaths. The effects were undoubtedly large for the other two Eras of Cohort "B" (RRs of 1.59 and 1.72). One reason for these differences may lie in the exclusion of deaths before the end of 1967 from the two groups recently at work and with comparatively low Relative Risks. In the two earlier Eras of Cohort "B", the intervals between x-ray and death were short for substantial proportions of the men, and "prediction" of mortality from radiographic changes may thus have been improved.

Table 10.1

RADIOLOGICAL ABNORMALITY AND TOTAL MORTALITY

		O	E	SMR	RR	χ^2
Cohort "A"	"Normal"	21	24.91	.84		
	"Less-than-normal"	109	104.04	1.05	1.24	0.83
Cohort "B"						
Era 1 *	"Normal"	306	301.49	1.01		
	"Less-than-normal"	110	68.20	1.61	1.59	17.67
Era 2	"Normal"	354	205.73	1.72		
	"Less-than-normal"	416	140.66	2.96	1.72	57.49
Era 3	"Normal"	131	153.03	.86		
	"Less-than-normal"	110	96.41	1.14	1.33	4.97
All Eras †	"Normal"	791	675.15	1.17		
	"Less-than-normal"	636	315.12	2.02	1.72	106.88

* From 1951

† The figures for Eras 1, 2 and 3 do not total to those for All Eras (except for observed deaths): expectations for Era 3 are low because the study interval when this Era was considered separately did not start until 1968; and the Relative Risks and χ^2 statistics are not, in any case, additive.

Table 10.2 gives distributions of man-years, accumulated in the comparative composite cohort analyses, by broad age groups, for "normals" and "less-than-normals" in Cohorts "A" and "B", the latter divided by Era. Those for Era 1 were for the period after 1950 only, and so for the complete study interval would have been weighted even more to the younger groups. The distributions of the four groups of "normals" were completely different, one from another, and those for the "less-than-normals" almost equally so. An important, but expected, finding was that the "less-than-normals" were consistently older on average than the "normals"; further, this was repeated for each radiological feature examined. It emphasises the importance of some form of age-standardization in order to facilitate comparisons, and confirms the necessity for ensuring that effects are maintained over all portions of a cohort's ageing through the diagonal band of a Lexis (1875) diagram.

In Table 10.3, the six readers are compared in terms of the "sensitivity" and "specificity" of the predictions of mortality possible from radiological findings; the usual definitions, as for example in Armitage (1971, p. 434), have been used, together with the index J (or sensitivity plus specificity, expressed as percentages, less 100 per cent), proposed by Youden (1950). This is rather arbitrary in giving equal weight to sensitivity and specificity which, in this instance, were at quite different levels - less than half the deaths were predictable, whereas nearly three quarters of survivors were among "normals" - but ranks the readers in an order similar to that suggested from a two-way plot. At first sight, an index J = 16.7 per cent is disappointing, but it must be appreciated that the radio-

Table 10.2

DISTRIBUTIONS OF MAN-YEARS BY AGE

	Cohort "A"	Cohort "B"		
		Era 1 ★	Era 2	Era 3
"Normals"				
Less than 45	49.9	36.2	19.7	-
45 through 64	43.1	60.8	65.9	93.3
65 and over	6.9	3.0	14.4	6.7
	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>
"Less-than-normals"				
less than 45	18.4	17.8	16.8	-
45 through 64	58.9	73.5	60.1	91.4
65 and over	22.6	8.8	23.1	8.6
	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>

★ From 1951

Reader	Outcome	Radiological finding			Sensitivity (%)
		Normal	Other	Total	
5	Alive	369	145	514	50.2
	Dead	125	126	251	
6	Alive	343	148	491	48.0
	Dead	146	135	281	
4	Alive	335	176	511	51.6
	Dead	124	132	256	
1	Alive	411	75	486	32.5
	Dead	158	76	234	
3	Alive	317	154	471	46.5
	Dead	142	123	265	
2	Alive	386	98	484	31.3
	Dead	176	80	256	
ALL	Alive	2,161	796	2,957	43.6
	Dead	871	672	1,543	

Table 10.3

"SENSITIVITY" AND "SPECIFICITY", BY READER

(Cohort "B")

Specificity (%)	Youden's J (%)
71.8	22.0
69.9	17.9
65.6	17.2
84.6	17.1
67.8	14.3
79.8	11.1
73.1	16.7

logical aim was not the prediction of mortality but the description of pneumoconiotic appearances. Further, it would not be unexpected were the relationships to be quite different when individual radiological features are evaluated in terms of deaths from specific causes; see the sections below on pneumoconiosis and lung cancer.

In the ILO U/C (1971) classification of radiographs (ILO, 1972) category 0/- is introduced in terms almost identical to those used by Bohlig *et al.* (1970) in publishing the U/C classification, except that they are called "very obviously normal" films where earlier the phrase "barndoor" normal of the original proposal (Liddell, 1963) had been retained. Table 10.4 differentiates subjects with such films among the "normals". The χ^2 statistics are calculated as for Table 10.1 i.e. on a purely internal basis. For Cohort "A", the SMRS were very similar. In assessment of films for Cohort "B", only Readers 1 and particularly 5 made substantial use of the 0/- category, and for both these readers the SMR for the "barndoor" normals was less than for the remainder of "normals", leading to Relative Risk for the latter of 2.75 for Reader 1 and 1.24 for Reader 5. Although there is no trace of statistical significance in the findings in Table 10.4, as indicated by the values of χ^2 reaching only 2.27, the tendencies for Readers 1 and 5 are suggestive that more common use of the category could lead to clearer differences. Bohlig *et al.* (1970) stated that "barndoor" normal films were usually from young subjects, but there has been some fear that the category 0/- could mask emphysema. The lower SMRs, which of course take age differences into account, might indicate that this last concern is not well founded.

Table 10.4

"BARNDOR" NORMAL FILMS AND TOTAL MORTALITY

		O	E	SMR	RR	χ^2
<u>Cohort "A"</u>	"Barndoor" normal	2	2.41	.83		
	Other normal	19	22.50	.84	1.02	0.001
<u>Cohort "B"</u>						
Reader 5	"Barndoor" normal	17	19.43	.87		
	Other normal	98	90.43	1.08	1.24	0.67
Reader 1	"Barndoor" normal	2	4.81	.42		
	Other normal	143	125.16	1.14	2.75	2.19
Others	"Barndoor" normal	4	2.43	1.65		
	Other normal	527	432.89	1.22	.74	0.36
All readers	"Barndoor" normal	23	26.67	.86		
	Other normal	768	648.48	1.18	1.37	2.27

10.3 Cause-specific mortality in the "less-than-normals"

Table 10.5 gives the numbers of deaths in each of 13 cause groups, together with the risk in the "less-than-normals" relative to the "normals" and the associated χ^2 statistic, calculated as previously. In Cohort "B", among those with radiographic changes, there were greatly enhanced risks (all with χ^2 values greater than that associated with the 0.1 per cent "significance level" in an independent test) of deaths from:- pneumoconiosis (RR = 11.75); respiratory tuberculosis (RR = 6.28); "other" respiratory conditions (RR = 2.29); cancer of the chest (RR = 3.24); and diseases of the heart (RR = 1.53). There also appeared to have been excesses in the "less-than-normals" of deaths from (Relative Risks in brackets):- cancer of oesophagus of stomach (1.58); cancer of colon or rectum (2.34); "other" cancers (1.44); accidents (1.58); and "other" known causes (1.53).

Few of these findings were repeated in Cohort "A": all three deaths from pneumoconiosis were indeed in the "less-than-normals", leading to a Relative Risk expressed as infinity (∞), because the SMR for "normals" was zero, but there were so few deaths that the value of χ^2 was small. Similar estimates of "infinite" Relative Risks, of accidents and of "other" known causes, were associated with higher values of χ^2 , although neither reached a conventional level of statistical significance.

10.4 Total mortality and specific radiographic changes

The first two lines of Table 10.6 are repeated from the first table in this chapter, except that the expected numbers of deaths (E) for Cohort "B" were obtained by summation over the three Eras, and so,

	Cohort "A"	
	$O_1 + O_2$	RR
Pneumoconiosis	3	∞
Cancer of the chest	22	.78
Respiratory tuberculosis	-	
Other respiratory conditions	6	1.03
Diseases of the heart	44	1.03
Cancer of oesophagus or stomach	5	∞
Cancer of colon or rectum	3	∞
Other abdominal cancers	5	.91
Cancer of the larynx	2	.23
Other cancers	11	.40
Cerebro-vascular diseases	5	.82
Accidents	6	∞
Other known causes	16	∞

Table 10.5
RADIOLOGICAL ABNORMALITY AND CAUSE-SPECIFIC MORTALITY

χ^2	Cohort "B" (1951-75)		
	$O_1 + O_2$	RR	χ^2
0.50	31	11.75	41.24
0.24	119	3.24	44.63
	40	6.28	37.28
0.00	67	2.29	12.17
0.01	566	1.53	25.25
1.08	53	1.58	2.79
0.66	28	2.34	5.34
0.01	21	1.34	0.43
1.31	4	2.21	0.66
2.23	93	1.44	3.02
0.03	101	1.17	0.59
2.59	110	1.58	5.24
3.85	183	1.53	8.12

Table 10.6

SPECIFIC RADIOGRAPHIC CHANGES AND TOTAL MORTALITY

		C o h o r t "A"					C o h o r t "B" (1951-75)				
		O	E	SMR	RR	χ^2	O	E	SMR	RR	χ^2
"Normal"		21	24.91	.84			791	660.25	1.20		
"Less-than-normal"		109	104.04	1.05	1.24	0.83	636	305.27	2.08	1.74	110.72
"Less-than-normal"											
with:-											
<u>Small</u>	absent	56	63.82	.88			253	143.52	1.76		
<u>opacities</u> (a)	present	53	40.21	1.32	1.56	3.44	383	161.75	2.37	1.98	120.30
<u>Large</u>	absent	103	100.09	1.03			589	296.42	1.99		
<u>opacities</u>	present	6	3.94	1.52	1.81	1.56	47	8.85	5.31	4.43	99.94
<u>Pleural</u>	absent	56	65.03	.86			331	169.47	1.95		
<u>changes</u> *	present	53	39.00	1.36	1.61	4.01	305	135.80	2.25	1.87	83.69
<u>Pleural</u>	absent	90	91.48	.98			544	257.92	2.11		
<u>calcification</u>	present	19	12.55	1.51	1.80	3.73	92	47.35	1.94	1.62	16.59
<u>"Additional</u>	absent	68	65.84	1.03			418	223.10	1.87		
<u>symbols"</u>	present	41	38.19	1.07	1.27	0.79	218	82.17	2.65	2.21	104.67

* Other than calcification

(a) For Cohort "A" includes $1 \leq \text{SSC} \leq 6$.

as explained in section 8.5, were slightly lower, both for "normals" and for "less-than-normals", than in Table 10.1; the SMRs are correspondingly a little higher, but the Relative Risk virtually unaffected.

For the remainder of this table the "less-than-normals" were subdivided according to the absence or presence of specific radiographic appearances, treating each feature one at a time. The Relative Risks and χ^2 statistics were calculated comparing those in whom a feature was present against the "normals"; on this basis, the Relative Risks were all higher than when presence of a feature was compared with its absence, whether or not another feature rendered such a film "less-than-normal". The procedure leads to a partition of that χ^2 statistic with two degrees of freedom which compares all three groups; the quoted χ^2 statistics, as before with one degree of freedom, were larger only when the value of RR was increased sufficiently to compensate for the smaller numbers obtained by the exclusion of those "less-than-normals" in whose films the specific feature was not recorded.

For each radiographic feature, the SMRs for those in whom it was present was higher than in the "normals", in both cohorts. This effect was clearly significant in Cohort "B" for all features. Even for pleural calcification, where the Relative Risk was only 1.62, the χ^2 statistic was large by conventional standards (16.59); χ^2 statistics were enormous, varying from 120.30 to 83.69, for small opacities (RR = 1.98), "additional symbols" (RR = 2.21), large opacities (RR = 4.43) and non-calcified pleural changes (RR = 1.87), respectively. (RR and χ^2 are not more closely correlated because of the differing numbers of deaths associated with each type of x-ray change.) For

Cohort "A", with many fewer deaths, χ^2 values were much smaller, but Relative Risks were not inconsiderable; they could probably be taken as "significant" for pleural changes without calcification (1.61) and with calcification (1.80) and for small opacities (1.56).

10.5 Total mortality and non-radiographic factors

The next three tables (10.7 through 10.9) deal with factors other than radiographic. For each factor separately, each cohort was divided into two sub-cohorts and the SMR in the second was related to that in the first. Although the initial classification by accumulated dust exposure had been into four sub-cohorts, the three with lowest exposures were found to differ only slightly in SMRs, and so they were re-combined to yield a comparison of those whose accumulated exposure was at least 300 mpcf.y against those with lower exposures. Correspondingly, those with only grade 1 breathlessness were grouped with those who did not report this symptom, to allow comparison against those with definite dyspnoea. Thus, in each section of the three tables, there were only two sub-cohorts to be contrasted, and the calculations of χ^2 could be on the same basis as for Table 10.1.

The SMR of men at Thetford Mines was a fraction lower than of those at Asbestos, in Cohort "A", but slightly higher in Cohort "B" (Table 10.7), while those with higher dust exposures had higher SMRs in both cohorts, RR = 1.21 in Cohort "A", and 1.59, with $\chi^2 = 75.37$, in Cohort "B". The lack of independence must be emphasised; dust exposures at Thetford Mines were on average greater than at Asbestos, and it seems likely that the observed higher risk at Thetford Mines in Cohort "B" was caused mainly by the heavier exposure rather than by

Table 10.7

TOTAL MORTALITY BY MINING AREA, DUST EXPOSURE AND SMOKING HABIT

	Cohort "A"					Cohort "B" (1951-75)				
	O	E	SMR	RR	χ^2	O	E	SMR	RR	χ^2
Asbestos	41	39.98	1.03			728	536.63	1.36		
Thetford Mines	89	88.97	1.00	.98	0.02	699	428.87	1.63	1.20	12.04
Accumulated dust exposure (mpcf.y)										
less than 300	77	82.08	.94			853	678.53	1.26		
at least 300	53	46.86	1.13	1.21	1.10	574	286.95	2.00	1.59	75.37
Smoking habit:										
non-, ex-, light	33	50.33	.66			494	459.65	1.07		
cigarettes *	97	78.61	1.23	1.88	10.18	885	493.42	1.79	1.67	84.99

* For Cohort "A", at least 13 cigarettes a day
 For Cohort "B", known cigarette smokers

"neighbourhood" or other environmental differences. Cigarette smokers had substantially worse SMRs in both cohorts compared with the remainder; that the Relative Risk was higher in Cohort "A" (1.88) than in Cohort "B" (1.67) may have something to do with the different classification of smoking habits indicated in the footnote to the table. This was much the most "significant" effect noted so far in Cohort "A", $\chi^2 = 10.18$, and was also associated with very large χ^2 , i.e. 84.99, in Cohort "B".

Tables 10.8 and 10.9 can only refer to the one cohort, "A", because corresponding information was not obtained for the other. Of symptoms, only breathlessness was definitely associated with enhanced mortality (RR = 1.49, $\chi^2 = 4.70$), but there were suggestions of positive effects associated with persistent cough (despite the unreliability of data transcription) and with wheezing. Mortality in those with sub-normal FVC was rather worse than in the others, but the other two lung function measurements were unrelated to mortality. Those who were overweight in 1967 or 1968 did not have an elevated risk.

Table 10.8

RESPIRATORY SYMPTOMS AND TOTAL MORTALITY

(Cohort "A")

	O	E	SMR	RR	χ^2
<u>Breathlessness</u>					
Absent or slight	87	96.89	.90		
Definite	43	32.05	1.34	1.49	4.70
<u>Persistent cough *</u>					
Absent	120	120.47	1.00		
Present	10	8.47	1.18	1.19	0.27
<u>Persistent phlegm *</u>					
Absent	124	120.33	1.03		
Present	6	8.62	.68	.68	0.89
<u>Wheezing</u>					
Absent	69	72.58	.95		
Present	61	56.36	1.08	1.14	0.55

* As explained in relation to Table 9.5, these symptoms cannot be considered reliable.

Table 10.9

LUNG FUNCTION, ADIPOSITY AND TOTAL MORTALITY

(Cohort "A")

	O	E	SMR	RR	χ^2
Forced Vital Capacity					
Normal	103	110.04	.94		
Sub-normal *	27	18.90	1.43	1.53	3.88
Ratio: FEV _{1.0} /FVC					
Normal	112	111.09	1.01		
Sub-normal *	18	17.85	1.01	1.00	0.00
Maximal mid-expiratory flow					
Normal	112	110.62	1.01		
Sub-normal *	18	18.32	.98	.97	0.01
Adiposity					
Normal	109	107.77	1.01		
Overweight *	21	21.17	.99	.98	0.01

* At least one standard deviation from "adjusted" mean

Chapter 11

FINDINGS II

11.1 Introduction

As explained in section 10.1, the present chapter is concerned with deaths from disease which might be expected to have been detected on the chest radiograph, either directly or through changes arising from the retention of asbestos dust. Sections 11.2 and 11.3 examine in some depth radiological findings in men whose deaths were certified as from pneumoconiosis and from cancer of the chest, respectively. The next section deals with mesothelioma, and the chapter ends with consideration of deaths from respiratory tuberculosis, other respiratory conditions and heart diseases.

11.2 Pneumoconiosis

Although fibrosis of the lung due to the inhalation of asbestos dust may lead to premature death which is not certified as due to pneumoconiosis, deaths which are coded to that cause remain those that one would expect to be best predicted by a classification of radiographic appearances considered to be due to the retention of dust in the lungs. This is confirmed by the high risks of death from pneumoconiosis in the "less-than-normals" relative to the "normals" seen in Table 10.5, and the ability of the presence of parenchymal and pleural changes to predict total mortality (Table 10.6). The present section

is concerned with deaths coded to pneumoconiosis; there were three such deaths in Cohort "A" and 31 in Cohort "B". Table 11.1 gives Relative Risks, for both cohorts, associated with the presence of each radiographic feature, and with mining area, comparing Thetford Mines against Asbestos, higher accumulated dust exposure and cigarette smoking. χ^2 calculations for the former were on the same basis as for Table 10.6 and for the latter on the same basis as for Table 10.1. Corresponding figures for those with symptoms, depressed lung function, or overweight are also given for Cohort "A"; χ^2 basis again as for Table 10.1.

Because there were only three deaths recorded as due to pneumoconiosis in Cohort "A", it would have been most unlikely that any value of χ^2 reached a conventional level of significance, even although for all three their films were "less-than-normal"; small opacities were recorded in all three films, and the χ^2 statistic is about as high as it would be possible to achieve, and so is at least suggestive, particularly when considered in conjunction with the very high value (86.60) for Cohort "B", wherein the Relative Risk was 21.58. In that cohort, there were also clear associations of high mortality and the presence of pleural changes other than calcification (RR = 21.07) and of "additional symbols" (RR = 19.17), and with high levels of accumulated dust exposure (RR = 8.78). Only four of the 31 deaths were in men in whom large opacities had been recorded, but the expectation was too small to be computed to two decimal places; this led to unmeasurably high SMR (and hence RR and χ^2), but the actual numbers suggest that too much reliance should not be placed on these facts. The higher SMR at Thetford Mines was again probably no more than a reflection of the higher dust exposures there. There were slight

Table 11.1

DEATHS FROM PNEUMOCONIOSIS
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	3		31	
	RR	χ^2	RR	χ^2
"Less-than-normal"	*	0.50	11.75	41.24
Small opacities	*	2.40	21.58	86.60
Large opacities	-	-	+	+
Pleural changes *	*	1.07	21.07	71.62
Pleural calcification	*	1.17	2.44	0.18
"Additional symbols"	*	0.39	19.17	39.55
Thetford Mines <i>cf.</i> Asbestos	.80	0.03	3.37	10.64
Accumulated dust exposure	3.00	0.89	8.78	37.35
Cigarette smoking	1.50	0.11	1.11	0.08
Breathlessness	0	1.09		
Persistent cough	0	0.23		
Persistent phlegm	0	0.23		
Wheezing	.67	0.11		
Depressed FVC	3.00	0.89		
Depressed ratio $FEV_{1.0}/FVC$	0	0.50		
Depressed MMF	0	0.50		
Overweight	3.00	0.89		

* other than calcification † see text

signs of a dust effect in Cohort "A", but the three cases were largely free of respiratory symptoms.

The next two tables (11.2 and 11.3) describe the radiographic changes seen in the films of the men who died from pneumoconiosis (codes 523 and 524 of the Seventh Revision of the International Classification of Diseases); for Cohort "A", the 18 readings, six per case, are presented in one-way distributions. From Table 11.2, it can be seen that parenchymal change was recorded in the majority of the readings, 14 (or 77.8 per cent) and 23 (or 74.2 per cent) in the two cohorts, but other changes in the absence of parenchymal change were rare. There were two and five assessments as normal (11.1 per cent and 16.1 per cent) in Cohorts "A" and "B".

Table 11.3 illustrates the recording of parenchymal change in the pneumoconiosis cases. In Cohort "A", only small opacities were recorded, all irregular (types s, t, u) rather than rounded; the profusion averaged 3.5 on the notional scale of Liddell and May (1966, p. 9), corresponding to a reading between 1/1 and 1/2, considerably higher than the average in other cases where small opacities were seen. The pattern in Cohort "B" was not dissimilar, but among the 23 readings of small opacities, there were three where rounded opacities (p, q, r) predominated, and four in which large opacities were seen, each time in association with small opacities of profusion at least 2/2. The average profusion of small opacities in the 23 films was 5.6 on the notional scale, close to 2/2 and even higher than in Cohort "A".

For further investigation, a control was selected for each case

Table 11.2

RADIOGRAPHIC CHANGES IN PNEUMOCONIOSIS DEATHS

	Cohort "A"	Cohort "B"
Number of deaths	3	31
Number of readings	3 x 6 = 18	31
<u>Type of change</u>		
Parenchymal and other	9	17
Parenchymal only	5	6
	<hr/> 14	<hr/> 23
Pleural only	2	1
	<hr/> 16	<hr/> 24
Other *	-	2
	<hr/> 16	<hr/> 26
No change	2	5
	<hr/> 18	<hr/> 31

* One case of left costophrenic angle obliteration, with one "additional symbol"; one case of a single "additional symbol".

Table 11.3

PARENCHYMAL CHANGES IN PNEUMOCONIOSIS DEATHS

Entries in square brackets concern large opacities,
A, B and C well-defined, D, E and F ill-defined.

Profusion of small opacities	Cohort "A"	Cohort "B"
(0/-)	-	-
(0/0)	-	-
0/1	2 (2t)	2 (1t, 1u)
1/0	2 (2s)	-
1/1	4 (3t, 1u)	4 (3t, 1u)
1/2	-	2 (1p, 1u)
2/1	-	1 (u)
2/2	2 (1t, 1u)	7 (1r, 2s, 1t, 3u) [2 (1A, 1E)]
2/3	1 (t)	1 (u) [1(D)]
3/2	1 (t)	2 (1q, 1u)
3/3	2 (1t, 1u)	4 (1s, 3u) [1(D)]
3/4	-	-
	14	23

in Cohort "B", as described in section 8.6, and some results from the case-control pairs are given in Tables 11.4 and 11.5. The former shows, reader by reader, the number of pairs in which pneumoconiotic change, i.e. small opacities, pleural thickening or ill-defined diaphragm or cardiac border, was:- (a) present in both members of the pair; (b) present only in the case; (c) present only in the control; and (d) absent in both. The appropriate test for association is that due to McNemar (1947), although the correction for continuity usually used should be halved (Pirie and Hamdan, 1972). This test is based solely on the disparate pairs, (b) and (c), and leads to yet another form of χ^2 statistic, i.e.

$$\chi^2 = \{ |(b) - (c)| - \frac{1}{2} \}^2 + \{ (b) + (c) \}$$

again with one degree of freedom. Numbers are too small for a test for each reader separately; pooling yields $\chi^2 = 11.07$, which can be taken as providing some confidence that the excess of pairs in (b) over those in (c), common to five of the readers, was not due to chance.

Table 11.5 classifies cases and controls, independently, by accumulated dust exposure and by smoking habit. For the one case with exposure apparently less than 30 mpcf.y, the last recorded job ended in September 1930 at Thetford Mines. Clearly this man could not have been x-rayed at that time, and there is obviously a gap in the recorded work history; it is not unlikely that he had had substantial exposure in the period between 1930 and the time of x-ray that would have placed him in a higher exposure category. However, even including him with exposure as recorded gives the Relative Risks as in the table, showing the clear dose-response relationship expected, as these men

	Pneumoconiotic change:-		
	In case:	Present	Absent
In control:	Present	Absent	Present
	(a)	(b)	(c)
Reader 1	-	2	-
Reader 2	-	2	-
Reader 3	-	4	-
Reader 4	3	1	1
Reader 5	3	3	-
Reader 6	1	5	1
ALL READERS	7	17	2

Table 11.4

RADIOGRAPHIC CHANGES IN PNEUMOCONIOSIS DEATHS, AND CONTROLS

(Small opacities or uncalcified pleural changes)

Absent Absent (d)	Number of case- control pairs
2	4
1	3
-	4
1	6
-	6
1	8
5	31

Table 11.5

ASBESTOS DUST EXPOSURE AND SMOKING HABIT
IN PNEUMOCONIOSIS DEATHS AND IN CONTROLS

Accumulated dust exposure (mpcf.y)	Cases	Controls	RR
Less than 30	1 *	7	1
30, less than 100	-	7	0
100, less than 300	6	7	6.0
300 or greater	24	10	16.8
	<hr/> 31	<hr/> 31	
Smoking habit	Cases	Controls	RR
Non-smoker	5	4	1
Not current cigarette smoker	9	11	0.6
Cigarette smoker	17	16	0.8
	<hr/> 31	<hr/> 31	

* See text

formed part of the "main mortality cohort" (McDonald and Liddell, 1978). Again the lack of a relationship between smoking and pneumoconiosis is confirmation of the findings in the entire "main mortality cohort" (McDonald *et al.*, 1979).

Finally, we wished to discriminate between those pneumoconiosis deaths in which the x-ray had shown pneumoconiotic change (as defined for Table 11.4) and the others. Table 11.6 shows that the 23 cases with pneumoconiotic change on the x-ray differed little from the other seven either in accumulated dust exposure or in interval between last recorded job and death.

11.3 Cancer of the chest

The investigation of cancer of the chest (i.e. deaths coded in the Seventh Revision of the International Classification of Diseases to: 162, malignant neoplasm of bronchus and trachea; 163, malignant neoplasm of lung, unspecified as to whether primary or secondary; or 164, malignant neoplasm of mediastinum) followed the same lines as that for pneumoconiosis deaths. The tables follow the same broad pattern as those illustrating section 11.2, and the same definitions have been used.

Table 11.7 shows that in Cohort "B", the presence of each radiographic feature was associated with an enhanced risk of chest cancer, the strongest association being with large opacities: $RR = 20.73$; $\chi^2 = 142.98$. There were also increased Relative Risks in the presence of "additional symbols", 5.27 with $\chi^2 = 55.24$, uncalcified pleural

Table 11.6

PNEUMOCONIOSIS DEATHS WITH AND WITHOUT RADIOGRAPHIC CHANGES

(Excluding one death with exposure less than 30 mpcf.y)

<u>Accumulated dust exposure (mpcf.y)</u>	<u>Changes:-</u>	
	<u>Present</u>	<u>Absent</u>
Less than 30	-	-
30, less than 100	-	-
100, less than 300	3	3
300 or greater	20	4
	<u>23</u>	<u>7</u>

<u>Interval between last recorded job and death (years)</u>	<u>Changes:-</u>	
	<u>Present</u>	<u>Absent</u>
Less than 5	13	4
5 or greater	10	3
	<u>23</u>	<u>7</u>

Table 11.7

DEATHS FROM CANCER OF THE CHEST
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
	22		119	
Number of deaths	RR	χ^2	RR	χ^2
"Less-than-normal"	.78	0.24	3.24	44.63
Small opacities	1.41	0.66	2.88	19.46
Large opacities	1.20	0.03	20.73	142.98
Pleural changes *	1.21	0.16	3.73	34.80
Pleural calcification	.75	0.13	2.82	5.89
"Additional symbols"	.25	2.11	5.27	55.24
Thetford Mines cf. Asbestos	1.21	0.16	1.59	6.48
Accumulated dust exposure	2.04	2.90	2.87	36.03
Cigarette smoking	4.11	6.10	3.35	30.33
Breathlessness	.87	0.07		
Persistent cough	.71	0.12		
Persistent phlegm	.68	0.14		
Wheezing	1.82	1.98		
Depressed FVC	1.69	1.10		
Depressed ratio $FEV_{1.0}/FVC$.61	0.44		
Depressed MMF	1.32	0.25		
Overweight	1.11	0.04		

* other than calcification

changes ($RR = 3.73$, $\chi^2 = 34.80$), small opacities ($RR = 2.88$, $\chi^2 = 19.46$), and perhaps pleural calcification ($RR = 2.82$, $\chi^2 = 5.89$). Higher accumulated dust exposure and cigarette smoking also led to higher SMRs ($RR = 2.87$ and 3.35 , respectively, with $\chi^2 = 36.03$ and 30.33), but the high Thetford Mines risk relative to Asbestos was, once more, probably due to the higher levels of dust exposure there, and related to the high risk in those with pleural calcification. In Cohort "A", the risk in comparatively heavy cigarette smokers relative to others was great enough, 4.11 , to yield a high value of χ^2 , 6.10 ; the Relative Risks in those with higher dust exposure and in those whose films showed parenchymal or pleural change, without calcification, were also greater than unity, as were those in men who reported wheeze or had low FVC.

The pattern of radiographic change in chest cancer cases (including two in Cohort "B" which occurred before 1951, but excluding three mesotheliomas in that cohort whose deaths had been coded 162 or 163), shown in Tables 11.8 and 11.9, was quite different from that in pneumoconiosis (Tables 11.2 and 11.3). First, there were much higher proportions of normal readings, i.e. 65 out of 132, or 49.2 per cent and 48 in 118, or 40.7 per cent, in the two cohorts, compared with 11.1 per cent and 16.1 per cent in pneumoconiosis. Secondly, the proportions of the chest cancer cases showing parenchymal changes were rather lower, i.e. 90 readings out of 250, or 36.0 per cent, than of pneumoconiosis cases, where there were 37 readings of parenchymal change out of 49, or 75.5 per cent. Thirdly, such parenchymal changes as were recorded were of substantially lower profusion of small opacities (averages corresponding to profusions of less than 1/1 and

Table 11.8

RADIOGRAPHIC CHANGES IN CHEST CANCER DEATHS

	Cohort "A"	Cohort "B"
Number of deaths	22	118 *
Number of readings	22 x 6 = 132	118
<u>Type of change</u>		
Parenchymal and other	29	26
Parenchymal only	22	13
	<hr/> 51	<hr/> 39
Pleural	15	18
	<hr/> 66	<hr/> 57
Costophrenic angle only	1	2
	<hr/> 67	<hr/> 59
"Additional symbol" only	-	11
	<hr/> 67	<hr/> 70
No change	65	48
	<hr/> 132	<hr/> 118

* Consisting of 119 cases in the years 1951 through 1975, plus two before 1951, less three mesotheliomas coded 162 or 163 (see Table 11.14).

Table 11.8

RADIOGRAPHIC CHANGES IN CHEST CANCER DEATHS

	Cohort "A"	Cohort "B"
Number of deaths	22	118 *
Number of readings	22 x 6 = 132	118
<u>Type of change</u>		
Parenchymal and other	29	26
Parenchymal only	22	13
	<hr/> 51	<hr/> 39
Pleural	15	18
	<hr/> 66	<hr/> 57
Costophrenic angle only	1	2
	<hr/> 67	<hr/> 59
"Additional symbol" only	-	11
	<hr/> 67	<hr/> 70
No change	65	48
	<hr/> 132	<hr/> 118

* Consisting of 119 cases in the years 1951 through 1975, plus two before 1951, less three mesotheliomas coded 162 or 163 (see Table 11.14).

Profusion
of small
opacities

C o h o r t "A"

(0/-)	-	
0/0	-	
0/1	16 (1p, 2q, 2s, 1(ps), 10t)	
1/0	10 (1p, 1(qs), 8t)	
1/1	19 (1p, 1q, 3s, 11t, 3u)	[1(D)]
1/2	3 (2t, 1u)	
2/1	-	
2/2	3 (2t, 1u)	
2/3	-	
3/2	-	
3/3	-	
3/4	-	

Table 11.9

PARENCHYMAL CHANGES IN CHEST CANCER DEATHS

C o h o r t "B"

6 [6 (1A, 3B, 1D, 1E)]
 6 (5t, 1u) [2 (1D, 1E)]

6 (1q, 1s, 3t, 1u) [1(B)]

5 (1p, 1q, 3t)

4 (1p, 1s, 2t) [2(D)]

2 (1p, 1q)

7 (1s, 5t, 1u) [1(D)]

1 (p) [1(A)]

2 (1p, 1s) [1(B)]

a little more than 1/1 in Cohorts "A" and "B", respectively), while the opacities were more frequently rounded (p, q, r), i.e. in 15 out of 84 readings of profusion at least 0/1 (17.9 per cent), compared with 3 out of 37 (8.1 per cent) in pneumoconiosis. Finally, in Cohort "B", there were 15 cases in which large opacities had been recorded, only three associated with small opacities of profusion 2/2 or greater; see also Table 11.12.

The numbers in Table 11.10 are just large enough to allow tests, of the sort described in relation to Table 11.4, reader by reader; for each reader, the number of case-control pairs in which radiographic change was present in the case but not in the control, column (b), was greater than the number in which the reverse was true, column (c), but only for Readers 6 and 2 was χ^2 substantial (7.52 and 5.56, respectively). However, pooling over all readers led to $\chi^2 = 16.54$, a little higher than for pneumoconiosis - because of the larger numbers rather than better discrimination.

Table 11.11 reveals the expected dose-response relationships for both dust exposure and smoking, but these two factors do not discriminate well between those cases whose x-rays were normal and others; see the upper part of Table 11.12. However, the shorter the interval between last recorded job (usually less than a year after the x-ray had been taken) and death, the lower the probability of the film being assessed as normal: for the four intervals in the lower part of Table 11.12, the proportions with normal films were 18.8 per cent, 44.4 per cent, 64.3 per cent and 70.0 per cent, as the intervals increased. In 11 of the 14 chest cancer cases in whose films "large

Radiographic change:-

In case:	Present	Present	Absent	Absent
	(a)	(b)	(c)	(d)
In control:	Present	Absent	Present	Absent
Reader 1	2	6	1	6
Reader 2	-	11	2	10
Reader 3	7	6	4	5
Reader 4	4	7	2	2
Reader 5	4	5	4	5
Reader 6	7	11	1	6
ALL READERS	24	46	14	34

Table 11.10

RADIOGRAPHIC CHANGES IN CHEST CANCER DEATHS, AND CONTROLS

(Any radiographic changes)

Number of case-
control pairs

15
23
22
15
18
25

118

Table 11.11

ASBESTOS DUST EXPOSURE AND SMOKING HABIT
IN CHEST CANCER DEATHS AND IN CONTROLS

Accumulated dust exposure (mpcf.y)	Cases	Controls	RR
Less than 30	18	25	1
30, less than 100	20	24	1.16
100, less than 300	17	21	1.12
300 or greater	63	48	1.82
	<u>118</u>	<u>118</u>	

Smoking habit *	Cases	Controls	RR
Non-smoker	6	8	} 1
Not current cigarette smoker	17	45	
Cigarette smoker	91	61	3.44
	<u>114</u>	<u>114</u>	

* Excluding four pairs in which habit was not known for case

Table 11.12

CHEST CANCER CASES WITH AND WITHOUT RADIOGRAPHIC CHANGES

Smoking habit	Accumulated dust exposure (mpcf.y)	Changes:-	
		Present	Absent
Not cigarettes	Less than 300	3 (2)*	3
	300 or greater	9 (6)	9
Cigarettes	Less than 300	30 (11)	16
	300 or greater	27 (14)	17
		<u>69 (33)</u>	<u>45</u>

* Numbers of cases in which small opacities were recorded

Interval between last recorded job and death (years)	Changes:-	
	Present	Absent
Less than 5	39 (11) †	9
5, less than 10	20 (1)	16
10, less than 20	5 (1)	9
20 or greater	6 (1)	14
	<u>70 (14)</u>	<u>48</u>

† Numbers of cases in which large opacities were recorded

Table 11.12

CHEST CANCER CASES WITH AND WITHOUT RADIOGRAPHIC CHANGES

Smoking habit	Accumulated dust exposure (mpcf.y)	Changes:-	
		Present	Absent
Not cigarettes	Less than 300	3 (2)*	3
	300 or greater	9 (6)	9
Cigarettes	Less than 300	30 (11)	16
	300 or greater	27 (14)	17
		69 (33)	45

* Numbers of cases in which small opacities were recorded

Interval between last recorded job and death (years)	Changes:-	
	Present	Absent
Less than 5	39 (11) ¶	9
5, less than 10	20 (1)	16
10, less than 20	5 (1)	9
20 or greater	6 (1)	14
	70 (14)	48

¶ Numbers of cases in which large opacities were recorded

opacities" had been assessed, the interval was less than five years; in the six cases with "large opacities" but no small opacities, the intervals were all short, three dying in the same year as that of last employment, two in the following year, and one in the year after that.

11.4 Mesothelioma

A total of six deaths within Cohorts "A" and "B" had been recognized, during the course of the main mortality study, as due to malignant mesothelioma, all of the pleura; one was in Cohort "A" and had been coded to cause 227 in the Seventh Revision of the International Classification of Diseases, and in Cohort "B" two had been coded to 162, one to 163 and two to 212. Table 11.13 gives the six readings of the film for the one case in Cohort "A". He died in 1972, aged 62; his first employment in the Quebec asbestos industry was in January 1928, giving an interval between first exposure and death of 44 years. At November 1966, his net service was 39 years, but the dust exposure accumulated until then was only 227 mpcf.y. The five cases in Cohort "B" are described in Table 11.14. The first six lines indicate the radiographic changes, and there follows a brief summary of other facts about each case.

One of the most interesting findings about asbestos-induced mesothelioma is the long latent period, i.e. interval between first exposure to asbestos and death, probably even longer for chrysotile than for crocidolite; see Figure 6.2 above. A total of twelve cases exposed to chrysotile only have now been ascertained among Quebec miners and millers; the six not reported here had had rather longer latent periods, ranging from 41 years to 56, with a median of 52 years.

Table 11.13

MESOTHELIOMA: ONE CASE IN COHORT "A"

Death in 1972, at age 62 years, coded "227"

Interval from first exposure to death: 44 years

Net service, at Thetford Mines: 31 years; 227 mpcf.y accumulated.

Cigarette smoker

Rdr	ROUNDED SMALL OPACITIES			IRREGULAR SMALL OPACITIES			LARGE OPACITIES		PLEURAL THICKENING			ILL. DIAHRAGM	ILL. DEFINED CARDIAC BORDER	PLEURAL CALCIFICATION				14917				
	Quality	Zone		Type	Zone		(a)	(b)	Causal angle	(c)	(d)			(e)		Diaphragm	Wall		Other	Grade	Symbol	Comments
A	+	/	/	/	/	/									R	L	I					
B	+	/	/	/	/	/						R ₁ L			R	L	I					
C	+	/	/	/	/	/									R	L	I					
D	+	/	/	/	/	/									R	L	I			✓		
E	+	/	/	/	/	/									R	L	I					
F	+	p	/	/	/	/									R	L	I					
	+	p	/	/	/	/	0	0	0	0	0	0	0	0				0	Cn	Co		
	±	q	1/0 1/1 1/2	1/0 1/1 1/2	1/0 1/1 1/2	1/0 1/1 1/2	A	D	R	R	R	R	R	R				1	Es	Ho		
	±	r	2/1 2/2 2/3	2/1 2/2 2/3	2/1 2/2 2/3	2/1 2/2 2/3	B	E	L	L	L	L	L	L				2	Od	Tb		
	U/R		3/2 3/3 3/4	3/2 3/3 3/4	3/2 3/3 3/4	3/2 3/3 3/4	C	F										3				

(a) Well defined

(c) Diffuse

(b) Poorly defined

(d) Plaques

(e) Grade

(a) Well defined (c) Diffuse
 (b) Poorly defined (d) Plaques
 (e) Grade

Table 11.14

MESOTHELIOMA: FIVE CASES IN COHORT "B"

	C a s e n u m b e r				
	1	2	3	4	5
Parenchymal change					
(type and profusion)	-	-	p: 1/0 t: 0/1	-	-
Thickening of pleural walls	-	-	-	-	-
Ill-defined diaphragm	-	R	-	-	-
Ill-defined cardiac border	-	-	-	-	-
Pleural calcification (grade)	-	3	-	-	-
"Additional symbols" (count)	1	-	-	-	-
Coded cause of death	162	162	212	212	163
Year of death	1956	1964	1967	1967	1975
Age at death (years)	40	57	73	57	64
Interval from first exposure to death (years)	21	45	30	31	52
Mining area (Asbestos or Thetford Mines)	TM	TM	TM	A	TM
Year of last employment	1955	1963	1962	1966*	1966*
Net service (years)	15	44	19	30	31
Accumulated dust exposure (mpcf.y)	71	353	52	622	684
Cigarette smoker	Yes	NK	Yes	Yes	Yes

* Still employed at November 1966

Only for one man in Cohort "B" was the latent period as long as the median for the complete group of twelve cases. This difference between the cases in the studies now being reported and the others is undoubtedly due to these others having completed their employment in the chrysotile mines and mills before radiology started there, and so being excluded from either study cohort.

11.5 Respiratory tuberculosis

Each of the next three sections is concerned with deaths from the three groups of causes mentioned in section 11.1 not already dealt with. Each group is the subject of a single table, with the same layout and definitions as for Table 11.1.

Although respiratory tuberculosis (Table 11.15) used to be a fairly common cause of death in Quebec, there were no deaths from this cause in Cohort "A", nor in Era 3 of Cohort "B". Not surprisingly, the risks of the "less-than-normals" were very much higher than those of the "normals". It is well-known that the radiological appearances of tuberculosis can be confused with pneumoconiotic change, particularly with large opacities (RR = 51.21), while the "additional symbols" (RR = 12.80) include means of recording diagnoses of tuberculosis. As the dust effect (RR = 1.64) was not nearly as large as that associated with abnormality of x-ray (RR at least 6.28), it seems possible that the high Relative Risks for small opacities (7.58) and for pleural changes (9.63 and 7.49) were artefactual rather than the results of heavy exposure to asbestos dust. The difference between Thetford Mines and Asbestos is probably a reflection of differences between the areas in the prevalence of tuberculosis in the general population, for

Table 11.15

DEATHS FROM RESPIRATORY TUBERCULOSIS
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	0		40	
	RR	χ^2	RR	χ^2
"Less-than-normal"			6.28	37.28
Small opacities			7.58	33.64
Large opacities			51.21	159.98
Pleural changes *			9.63	51.89
Pleural calcification			7.49	10.96
"Additional symbols"			12.80	64.88
Thetford Mines <i>cf.</i> Asbestos			2.06	5.41
Accumulated dust exposure			1.64	2.29
Cigarette smoking			1.85	3.22
Breathlessness				
Persistent cough				
Persistent phlegm				
Wheezing				
Depressed FVC				
Depressed ratio $FEV_{1.0}/FVC$				
Depressed MMF				
Overweight				

* other than calcification

it was observed also in the main mortality study (McDonald *et al.*, 1979) for all male workers regardless of exposure. The smoking effect was so small compared with all the others that it should probably not be given much weight.

11.6 Other respiratory conditions

Deaths from other respiratory conditions (Table 11.16) also seem to have been predictable from radiographic changes and once more there appears to have been some misdiagnosis, either on the x-ray or on death certification, where "large opacities" are concerned. In Cohort "B", the dust effect was considerable ($RR = 1.85$, $\chi^2 = 6.47$), and so the high Relative Risks for the men with pneumoconiotic changes (RRs 2.99 and 3.27 for parenchymal and pleural changes; χ^2 values 18.21 and 20.61) may well have been reflections of heavier exposure. The Relative Risk for smokers may have been because of chronic bronchitis.

In Cohort "A", only pleural calcification, among radiographic features, was associated with high risk; no explanation has been found. The most marked findings in this cohort were Relative Risks of 5.95 and 6.21 for depressed FVC and MMF: they are both eminently reasonable, as are the high Relative Risks, even if without high values of χ^2 , associated with breathlessness (2.87), persistent phlegm (2.60), wheeze (1.26) and $FEV_{1.0}/FVC$ (3.10).

11.7 Heart disease

Although relative risks of death from heart disease (Table 11.17) were not generally as great as for the conditions just discussed, the

Table 11.16

DEATHS FROM OTHER RESPIRATORY DISEASES
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	6		67	
	RR	χ^2	RR	χ^2
"Less-than-normal"	1.03	0.00	2.29	12.17
Small opacities	1.05	0.00	2.99	18.21
Large opacities	0	0.16	11.82	34.04
Pleural changes *	1.07	0.00	3.27	20.61
Pleural calcification	3.30	1.94	1.58	0.55
"Additional symbols"	1.64	0.26	1.90	2.10
Thetford Mines <i>cf.</i> Asbestos	.92	0.01	.98	0.00
Accumulated dust exposure	.31	1.28	1.85	6.47
Cigarette smoking	.68	0.23	1.39	1.74
Breathlessness	2.87	1.83		
Persistent cough	0	0.43		
Persistent phlegm	2.60	0.82		
Wheezing	1.26	0.08		
Depressed FVC	5.95	6.17		
Depressed ratio $FEV_{1.0}/FVC$	3.10	1.90		
Depressed MMF	6.21	6.25		
Overweight	0	1.19		

* other than calcification

Table 11.17

DEATHS FROM HEART DISEASE
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
	44		566	
Number of deaths	RR	χ^2	RR	χ^2
"Less-than-normal"	1.03	0.01	1.53	25.25
Small opacities	1.62	1.87	1.71	27.92
Large opacities	2.25	1.76	1.12	0.05
Pleural changes *	1.44	0.93	1.54	13.96
Pleural calcification	1.64	1.11	1.34	2.25
"Additional symbols"	1.32	0.50	1.98	30.46
Thetford Mines <i>cf.</i> Asbestos	.96	0.01	1.13	1.96
Accumulated dust exposure	1.42	1.36	1.57	27.90
Cigarette smoking	1.38	1.00	1.78	41.95
Breathlessness	2.26	7.58		
Persistent cough	1.42	0.46		
Persistent phlegm	0	3.17		
Wheezing	1.39	1.20		
Depressed FVC	1.29	0.42		
Depressed ratio $FEV_{1.0}/FVC$.79	0.23		
Depressed MMF	.60	0.94		
Overweight	1.12	0.08		

* other than calcification

values of χ^2 are larger because they are based on so many more deaths. The dust and pneumoconiotic effects may be explicable by diagnosis of heart disease in deaths accelerated by pneumoconiosis in those heavily exposed to asbestos. The "additional symbols" associated with high risk may have included those relating to heart conditions, e.g. cor pulmonale or enlarged heart. The smoking effect was to have been expected from other studies in asbestos workers (e.g. McDonald *et al.*, 1979) and in other populations (see several reports summarized by Holman, 1976), as was the high Relative Risk for those who reported breathlessness (see, for example, Higgins and Keller, 1970).

Chapter 12

FINDINGS III

12.1 Introduction

It seems most unlikely that any manifestation of the remaining groups of causes of death could be discernible on an x-ray of the chest. However, in dust related conditions, there might be pneumoconiotic changes as indirect signs of disease. As in the previous chapter, each group of causes of death is the subject of a table on the same lines as Table 11.1.

12.2 Cancer of the gastro-intestinal tract

The pattern of relationships between dust and *cancer of the oesophagus or stomach* (Table 12.1) are far from clear. In Cohort "B", the effect of exposure to asbestos dust ($RR = 2.76$, $\chi^2 = 14.79$) was rather larger than was to have been expected from the main mortality study (McDonald and Liddell, 1978), but most of the pneumoconiotic x-ray appearances with high Relative Risks probably arose from the dust exposure. The high Relative Risk for pleural calcification (3.45), together with the high risk at Thetford Mines (2.06), where most of the calcification is concentrated, might suggest a common aetiology, conceivably in the drinking water supplies. It is not impossible that the high risks in Cohort "A" for the overweight ($RR = 3.38$) and those with persistent cough ($RR = 3.63$) reflect true underlying relation-

Table 12.1

DEATHS FROM CANCER OF OESOPHAGUS OR STOMACH
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
	5		53	
Number of deaths	RR	χ^2	RR	χ^2
"Less-than-normal"	∞	1.08	1.58	2.79
Small opacities	∞	0.88	2.06	5.87
Large opacities	-	-	4.70	4.82
Pleural changes *	∞	0.92	2.44	9.42
Pleural calcification	-	-	3.45	10.85
"Additional symbols"	∞	0.96	0.76	0.17
Thetford Mines <i>cf.</i> Asbestos	1.81	0.29	2.06	6.76
Accumulated dust exposure	0	3.08	2.76	14.79
Cigarette smoking	∞	3.29	1.56	2.47
Breathlessness	0	1.73		
Persistent cough	3.63	1.52		
Persistent phlegm	0	0.37		
Wheezing	.31	1.20		
Depressed FVC	0	0.86		
Depressed ratio $FEV_{1.0}/FVC$	1.55	0.16		
Depressed MMF	1.52	0.14		
Overweight	3.38	2.01		

* other than calcification

ships.

For *cancer of the colon or rectum* (Table 12.2), the dust effect in Cohort "B" was quite small and could hardly account for the Relative Risks of those with pneumoconiotic changes on the x-ray. However, the χ^2 values were not large, whereas those in Cohort "A" for breathlessness and depressed FVC were. It is not clear why cancer of the lower gastro-intestinal tract should cause respiratory signs and symptoms.

Table 12.3 deals with *other causes of the abdomen*, i.e. malignant neoplasms of:- biliary passages and of liver, stated to be primary site (155); liver, secondary or unspecified (156); pancreas (157); peritoneum (158); or unspecified digestive organs (159). In view of the comparatively low values of the χ^2 statistics, particularly in relation to dust exposure, it would seem that the chest x-ray cannot materially affect prediction of mortality from these causes.

12.3 Cancer of the larynx

Laryngeal cancer (Table 12.4) has been cited (see Chapter 2) as one response to asbestos exposure, but here the only sign of a dust effect in the admittedly very few cases in either cohort was in the reverse direction. On the other hand, McDonald and Liddell (1978) showed no excess of cancer of the larynx, but a very clear dose-response relationship with cigarette smoking, which is in no way contradicted by the present information. Nor is it surprising that this disease should be associated with dyspnoea. However, the lack of any other important association of laryngeal cancer was according to ex-

Table 12.2

DEATHS FROM CANCER OF COLON OR RECTUM
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	3		28	
	RR	χ^2	RR	χ^2
"Less-than-normal"	∞	0.66	2.34	5.34
Small opacities	∞	1.51	1.76	1.07
Large opacities	-	-	0	0.12
Pleural changes *	∞	0.39	2.42	3.32
Pleural calcification	∞	2.11	2.94	2.47
"Additional symbols"	∞	1.62	2.31	1.81
Thetford Mines <i>cf.</i> Asbestos	.23	1.76	1.85	2.60
Accumulated dust exposure	3.29	1.06	1.44	0.89
Cigarette smoking	∞	1.96	.74	0.62
Breathlessness	∞	8.81		
Persistent cough	0	0.21		
Persistent phlegm	0	0.22		
Wheezing	.64	0.14		
Depressed FVC	11.71	6.53		
Depressed ratio $FEV_{1.0}/FVC$	0	0.48		
Depressed MMF	0	0.49		
Overweight	0	0.59		

* other than calcification

Table 12.3

DEATHS FROM OTHER CANCERS OF THE ABDOMEN
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
	5		21	
	RR	χ^2	RR	χ^2
Number of deaths				
"Less-than-normal"	.91	0.01	1.34	0.43
Small opacities	1.18	0.02	1.27	0.16
Large opacities	0	0.16	0	0.16
Pleural changes *	1.22	0.03	2.28	3.22
Pleural calcification	0	0.37	3.34	4.15
"Additional symbols"	1.24	0.04	1.89	1.01
Thetford Mines <i>cf.</i> Asbestos	∞	2.24	1.12	0.07
Accumulated dust exposure	.43	0.61	1.20	0.15
Cigarette smoking	.97	0.00	2.70	4.03
Breathlessness	0	1.69		
Persistent cough	0	0.35		
Persistent phlegm	3.52	1.45		
Wheezing	.84	0.04		
Depressed FVC	0	0.87		
Depressed ratio $FEV_{1.0}/FVC$	0	0.81		
Depressed MMF	0	0.83		
Overweight	0	1.00		

* other than calcification

Table 12.4

DEATHS FROM LARYNGEAL CANCER
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	2		4	
	RR	χ^2	RR	χ^2
"Less-than-normal"	.23	1.31	2.21	0.66
Small opacities	.59	0.28	4.10	2.73
Large opacities	0	0.36	0	0.02
Pleural changes *	0	1.66	2.55	0.57
Pleural calcification	0	0.94	0	0.09
"Additional symbols"	0	1.66	0	0.16
Thetford Mines <i>cf.</i> Asbestos	∞	0.92	3.71	1.49
Accumulated dust exposure	0	1.18	.81	0.03
Cigarette smoking	∞	1.26	∞	3.58
Breathlessness	∞	5.78		
Persistent cough	0	0.15		
Persistent phelgm	0	0.15		
Wheezing	∞	2.52		
Depressed FVC	0	0.33		
Depressed ratio $FEV_{1.0}/FVC$	0	0.33		
Depressed MMF	0	0.33		
Overweight	0	0.41		

* other than calcification

pectation.

12.4 Other causes

Again, with *other cancers* (Table 12.5), it is not surprising that none of the tabulated Relative Risks appears of significance.

It is difficult to see how *cerebro-vascular diseases* (Table 12.6) could be associated with exposure to asbestos dust, but the Relative Risk in Cohort "B" was not trivially enhanced; there was also an elevated risk, in both cohorts, among those in whose films large opacities had been recorded. These films require careful study to see whether there is any possibility of predicting strokes. The Relative Risks for certain respiratory signs and symptoms in Cohort "A" may well appear important only because they are based on so few deaths due to cerebro-vascular disease.

In considering Table 12.7, it is important to appreciate that the *accidents* included all deaths coded 800-999; only a minority were accidents at work, and by no means all of these occurred while the man was employed in the asbestos industry. Compared with the causes of death discussed in the last few pages, there is even less reason to believe that the x-ray could predict mortality from accidents. Fortunately, there are few high values of χ^2 ; on the other hand, there are several contradictions, e.g. in the high Relative Risk for small opacities without a corresponding effect of higher dust exposure. Nor can the high risks for smokers be adequately reconciled. The pattern is only confused by the differences between the two cohorts.

Table 12.5

DEATHS FROM OTHER CANCERS
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
Number of deaths	11		93	
	RR	χ^2	RR	χ^2
"Less-than-normal"	.40	2.23	1.44	3.02
Small opacities	.15	3.52	1.50	2.42
Large opacities	1.48	0.26	1.34	0.07
Pleural changes *	.46	1.40	1.52	2.33
Pleural calcification	0	1.15	.96	0.01
"Additional symbols"	.16	3.40	1.13	0.09
Thetford Mines <i>cf.</i> Asbestos	.79	0.14	.84	0.70
Accumulated dust exposure	.64	0.45	1.14	0.34
Cigarette smoking	1.73	0.67	1.42	2.71
Breathlessness	.30	1.50		
Persistent cough	3.13	2.36		
Persistent phlegm	1.38	0.10		
Wheezing	.48	1.22		
Depressed FVC	0	1.87		
Depressed ratio $FEV_{1.0}/FVC$	2.34	1.67		
Depressed MMF	.61	0.23		
Overweight	0	2.17		

* other than calcification

Table 12.6

DEATHS FROM CEREBRO-VASCULAR DISEASES
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

	Cohort "A"		Cohort "B"	
	5		101	
Number of deaths	RR	χ^2	RR	χ^2
"Less-than-normal"	.82	0.03	1.17	0.59
Small opacities	0	0.77	1.23	0.69
Large opacities	5.25	3.40	4.43	9.90
Pleural changes *	1.07	0.00	.98	0.00
Pleural calcification	0	0.45	1.08	0.03
"Additional symbols"	1.08	0.00	1.65	3.18
Thetford Mines <i>cf.</i> Asbestos	.30	1.90	1.34	2.17
Accumulated dust exposure	1.03	0.00	1.63	6.07
Cigarette smoking	2.70	0.85	1.09	0.17
Breathlessness	4.29	3.02		
Persistent cough	0	0.37		
Persistent phelgm	0	0.39		
Wheezing	5.06	2.61		
Depressed FVC	9.02	8.56		
Depressed ratio $FEV_{1.0}/FVC$	1.57	0.16		
Depressed MMF	1.58	0.17		
Overweight	1.26	0.04		

* other than calcification

Table 12.7

DEATHS FROM ACCIDENTS
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	6		110	
	RR	χ^2	RR	χ^2
"Less-than-normal"	∞	2.59	1.58	5.24
Small opacities	∞	1.54	1.97	8.51
Large opacities	-	-	1.29	0.05
Pleural changes *	∞	0.43	1.39	1.17
Pleural calcification	∞	2.08	.64	0.34
"Additional symbols"	∞	1.66	1.41	0.86
Thetford Mines <i>cf.</i> Asbestos	2.10	0.48	1.00	0.00
Accumulated dust exposure	3.02	2.02	1.16	0.49
Cigarette smoking	1.07	0.01	1.80	7.46
Breathlessness	1.99	0.66		
Persistent cough	0	0.41		
Persistent phlegm	0	0.34		
Wheezing	1.52	0.26		
Depressed FVC	1.15	0.02		
Depressed ratio $FEV_{1.0}/FVC$	1.28	0.05		
Depressed MMF	1.12	0.01		
Overweight	1.15	0.02		

* other than calcification

The last table (12.8) deals with deaths from *causes known but not included in any group already discussed*. Although the Relative Risks for the higher dust exposure sub-cohorts were not particularly high, those for several radiographic changes were, and that for small opacities in Cohort "B" is inexplicable. The high risks, in both cohorts, among those whose films were read as having "additional symbols", might be explained by careful consideration of the particular "symbol" and the exact code of the cause of death. The smoking effect, present in both cohorts, could possibly be elucidated by similar detailed enquiry.

Table 12.8

DEATHS FROM OTHER KNOWN CAUSES
RELATED TO RADIOGRAPHIC CHANGES AND OTHER FACTORS

(Relative Risks, and χ^2 statistics)

Number of deaths	Cohort "A"		Cohort "B"	
	16		183	
	RR	χ^2	RR	χ^2
"Less-than-normal"	∞	3.86	1.53	8.12
Small opacities	∞	1.24	1.86	13.44
Large opacities	-	-	2.75	3.78
Pleural changes *	∞	6.61	1.22	0.73
Pleural calcification	∞	6.88	1.80	3.98
"Additional symbols"	∞	4.12	2.16	13.74
Thetford Mines <i>cf.</i> Asbestos	.75	0.32	1.17	1.08
Accumulated dust exposure	1.06	0.01	1.15	0.76
Cigarette smoking	2.76	2.74	1.51	7.31
Breathlessness	1.01	0.00		
Persistent cough	.94	0.00		
Persistent phlegm	.93	0.01		
Wheezing	.43	2.26		
Depressed FVC	1.35	0.22		
Depressed ratio $FEV_{1.0}/FVC$.89	0.02		
Depressed MMF	.86	0.04		
Overweight	1.18	0.07		

* other than calcification

Chapter 13

S U M M A R Y O F F I N D I N G S

13.1 Introduction; total mortality

This chapter summarizes briefly the findings described in the preceding pages. Synthesis and discussion are in Chapter 14.

Those whose chest radiographs revealed abnormality of any feature (small opacities, large opacities, pleural changes with or without calcification, or additional symbols) had Relative Risks of total mortality greater than unity, substantially so for all features in Cohort "B"; in Cohort "A", the Relative Risks were generally rather smaller, but only the comparatively few deaths appeared to prevent "significance".

In Cohort "A", cigarette smoking was associated with the most significant Relative Risk (1.88, $\chi^2 = 10.18$), more so than for any of the radiographic changes and considerably greater than that for the men most heavily exposed to dust (RR = 1.21, $\chi^2 = 1.10$). Relative Risk of death from all causes in cigarette smokers was slightly less pronounced in Cohort "B" (1.67), but the dust effect was almost as large (1.59), and both were associated with very large values of χ^2 . The dust effect in Cohort "B" probably accounted for the higher SMR at Thetford Mines than at Asbestos, in that cohort. In Cohort "A",

those with dyspnoea and depressed FVC also had enhanced Relative Risks.

13.2 Asbestos-related diseases of the respiratory system

The radiographs of those who died from *pneumoconiosis* generally showed parenchymal change, often well advanced. The Relative Risk of pneumoconiosis in those more heavily exposed to asbestos dust was high in both cohorts, but considerably less than the Relative Risk of those with pneumoconiotic changes. Smoking was not a factor, and the three cases in Cohort "A" were largely asymptomatic.

The great majority of the men who died from *cancer of the chest* were cigarette smokers, or had had substantial exposure to asbestos dust, or both. In both cohorts, cigarette smokers had a higher Relative Risk than those with heavier exposure, markedly so in Cohort "A" (RRs of 4.11 and 2.04, respectively), where none of the Relative Risks for radiographic change were very great. Perhaps because of the larger dust effect in Cohort "B", some of the Relative Risks for radiographic changes were considerable, with that for "large opacities" dominating. This last may well have been recognition, on the x-ray, of the malignancy itself; for those in whom "large opacities" were diagnosed, the interval between x-ray and death was usually short. In both cohorts, only about half the x-ray readings were of pneumoconiotic change, and it was generally not advanced.

There were only six *mesotheliomas*, one in Cohort "A", whose film at least six years before death showed bilateral calcified plaques, and five in Cohort "B", with highly variable x-ray findings. The very short duration of this illness, after diagnosis, means that the changes

on a routine x-ray taken during employment are likely to be largely irrelevant. The latent periods, between first asbestos employment and death, were rather shorter than in the remainder of those in the "main mortality cohort" who died from this malignancy.

13.3 Other respiratory diseases; heart disease

There were forty cases of *respiratory tuberculosis* in Cohort "B", all before 1967. Very high Relative Risks were found for all radiographic features, particularly for "large opacities" (perhaps again with some element of mis-diagnosis) and "additional symbols" (probably including those specific for tuberculosis, i.e. tba and tb).

The Relative Risks of *other respiratory diseases* in Cohort "A" were high for men with depressed lung function (MMF: 6.21; FVC: 5.95; $FEV_{1.0}/FVC$: 3.10) and dyspnoea (2.87); however, there was a low Relative Risk for those with heavy dust exposure and little excess risk associated with x-ray change. In Cohort "B", on the other hand, there was a considerable dust effect, and, probably as a result of this, high Relative Risks for large opacities, pleural changes (without calcification) and small opacities.

Death at work, or shortly after ending employment, was a criterion for exclusion from Cohort "A", but not from Eras 1 and 2 of Cohort "B". Some deaths ascribed to *heart disease* may well have been due to the after-effects of dust retention, and this is substantiated by high Relative Risks both among the heavily exposed and associated with small opacities, in both cohorts. Smokers also had high Relative Risks of heart disease, as has been shown in many other studies (see review by

Holman, 1976). Those in Cohort "A" who reported breathlessness also had high risk of death from heart disease.

13.4 Other cancers

The patterns with cancers of the *gastro-intestinal tract* are confused. For the upper tract (oesophagus and stomach), there was a major dust effect in Cohort "B" and some high risks associated with changes on chest x-ray, for which no explanation has been found. For the lower tract (colon and rectum), there were dust effects in both cohorts, together with high risks associated with pleural changes and, in Cohort "A", with breathlessness and depressed FVC. For other abdominal cancers, there were no clear-cut findings.

There were only six *cancers of the larynx*, all among smokers, confirming the dose-response relationship found by McDonald *et al.* (1979), while no marked excess, nor relation to dust exposure or x-ray changes, again confirmed earlier findings. The two cases in the smaller cohort reported breathlessness and wheeze.

No consistent findings were observed with *cancers of other sites*.

13.5 Strokes; accidents; other causes

Strokes and accidents should surely be unrelated to asbestos exposure or to x-ray change. However, for *cerebro-vascular diseases*, the Relative Risks for those with large opacities were high in both cohorts; in Cohort "A", so were the risks of those who were breathless, wheezed or had depressed FVC. Again, Relative Risks for *accidents* (including, but by no means dominated by, accidents at work in

the asbestos industry) were high for those with small opacities and, in Cohort "B", for smokers.

The Relative Risks for the *other causes* of death not so far summarized were high, in both cohorts, for men whose radiographs showed "additional symbols", small opacities, and pleural calcification, and for smokers.

13.6 Conclusion

Most of the findings summarized in sections 13.1 through 13.3 could be taken as validation of the system of radiological classification. Some of those in sections 13.4 and 13.5 are difficult to explain and require further investigation.

Chapter 14

DISCUSSION, SYNTHESIS AND RECOMMENDATIONS

14.1 Introduction

This has been the report of research aimed at answering specific questions about the prediction of mortality in asbestos workers from changes observed in radiographs of men while still employed. The next sections examine the weaknesses and strengths, both of materials and of methods, for these purposes. Section 14.2 shows how the present study cohorts would not have been suitable for a general investigation of mortality, but were of great strength for the current objectives. Section 14.3 emphasises the limitations of the commonly used *a priori* form of reasoning and highlights the need for the adopted strengthening by use of *a posteriori* methods.

Premature death is the end-point of a disease process which may have been initiated or accelerated by exposure to agents such as inhaled asbestos dust or cigarette smoke, and which may have been manifest, during life, by symptoms or signs. Severe exposure to asbestos dust has long been known to be associated with increased prevalence of dyspnoea, and of radiographic changes in the parenchyma of the lungs, and of their pleura, and with excess mortality from pneumoconiosis, cancer of the chest, malignant mesothelial tumours of the pleura (and sometimes of the peritoneum), and certain other causes. Cigarette

smoking can lead to respiratory symptoms, depressed lung function, and increased mortality from lung cancer, coronary heart disease, and some other causes; such effects may be synergistic with those of asbestos exposure. Section 14.4 considers total mortality in relation to various signs and symptoms.

The successes and failures of radiology as a predictive tool are discussed in the following sections, 14.5, 14.6, 14.7, dealing with pneumoconiosis and related conditions, neoplasia, and other causes of death, respectively. The next sections review the validation of the current radiographic classification of dust-related chest conditions and discuss its use for the surveillance of the asbestos worker.

The chapter ends by considering outstanding gaps in knowledge, with recommendations as to how they might be filled.

14.2 Mortality in relation to dust exposure, smoking and mining area

The continuing study of the "main mortality cohort" has shown clear excesses of deaths from certain causes, with dose-response relationships, as summarized by McDonald and Liddell (1978). The two present study cohorts, "A" and "B", were selected to achieve specific objectives; they were not intended to provide any substitute for a general investigation of mortality in relation to factors such as accumulated dust exposure and cigarette smoking. Nevertheless, basic findings of this nature were very similar to those seen in the entire cohort of nearly eleven thousand workers. Had they not been so, serious doubts would have been cast on the utility of the present

research materials. In fact, both cohorts had strengths and weaknesses; particular concerns are with the periods of follow-up and the definitions of study intervals.

Cohort "A" was comparatively small and the period of follow-up was short. Deaths from all causes numbered only 130, but many other studies have been based on even smaller numbers. A more important deficiency was that, by definition of this cohort, any deaths occurring within a short interval after the last available radiograph were excluded; see below. Total mortality was close to expectation, but there were excesses due to pneumoconiosis and cancer of the chest. The three deaths from pneumoconiosis were among men with heavier dust exposure; the 22 deaths from chest cancer almost entirely in men who had been cigarette smokers, or had had heavier dust exposure, or both.

Cohort "B" was almost half the size of the "main mortality cohort"; however, relative to that cohort, there were certain selection biases. First, a rather higher than representative proportion of men had worked at Asbestos, because radiology had started there several years earlier than at Thetford Mines; thus some of the highest dust exposures were excluded. Secondly, in order to have had an x-ray while employed, the men were considerably younger, on average, than those in the "main mortality cohort"; see Table 14.1. Thirdly, as discussed in section 9.5 above, the selection procedure led to the inclusion of all men who died at work or shortly afterwards; this was the reverse of the situation in Cohort "A", and is also discussed below. Not least because of these earlier deaths, mortality from all causes was higher than expected in Quebec; there were excesses

Table 14.1

DATES OF BIRTH: COHORT "B" AND "MAIN MORTALITY COHORT"

	Cohort "B"	"Main mortality cohort"
Number of men	4,559	10,939
Percentage distribution by quinquennium of birth		
1891 through 1895	7.2	13.8
1896 through 1900	9.3	17.7
1901 through 1905	10.2	18.0
1906 through 1910	15.7	16.7
1911 through 1915	25.6	16.0
1916 through 1920	32.0	17.7
	<hr/> 100 <hr/>	<hr/> 100 <hr/>

from pneumoconiosis and related conditions (respiratory tuberculosis, "other" respiratory conditions and heart diseases) and from cancer of the chest and other sites for which asbestos has been implicated, particularly of oesophagus and stomach. Relations with dust exposure and smoking were found more-or-less as could have been forecast from the main studies.

14.3 Limitations of a *priori* argument

The main methods of analysis followed convention in that they used *a priori* reasoning, classifying the men into sub-cohorts according to the values of certain factors, and following each sub-cohort separately. Because of the many factors to be examined, each classification (with a few exceptions) had to be carried out without regard for any other, so that when factors were interrelated it became impossible to disentangle effects. This is a well-known disadvantage of the procedure, and there is no reliable means of overcoming it when cross-classification by two or more factors creates sub-cohorts so small that there are too few deaths within them to be reliable, particularly when any specific cause of death is under consideration. Methods of analysis such as GLIM (Nelder, 1975) attempt to deal with the problem by fitting models to the re-grouped sub-cohorts, and then seeking signs, in the full detail, of divergence from the model; however, this cannot be very revealing for the same reason, i.e. small unreliable cells in the multi-dimensional array.

The use of *a posteriori* methods - examining factors of interest among the cases, often in comparison against controls - can be more revealing and was adopted for the investigation of the more important

causes of death. Only where case-control studies have been carried out can we make statements on the sensitivity and specificity of the radiological system in predicting mortality.

One example of the problem of disentangling effects is afforded by the apparent differences between the two mining areas, Asbestos and Thetford Mines, in mortality from pneumoconiosis. There were 31 such deaths in Cohort "B", 22 of them from Thetford Mines, a disproportionately high number. However, this was undoubtedly the more dusty area and the need was to determine whether area or dust was the causal factor. When a control was chosen for each case, it was found that 18 of the controls were also from Thetford Mines; the number of cases from Thetford Mines with a control from Asbestos was eight, and the reverse occurred four times, so that, in the McNemar test based on the disparate case-control pairs, the test statistic was $\chi^2 = 1.02$, which with one degree of freedom has an associated P-value of about thirty per cent, i.e. without trace of significance. In other words, it would seem likely that the differences between pneumoconiosis cases and their controls were in the dust exposures (see the large differences in Table 11.5) and not in the areas where the men had worked.

14.4 Total mortality in relation to signs and symptoms

Review of the literature relating to non-exposed populations suggests that certain symptoms and lung function tests may predict mortality from respiratory conditions and also from heart diseases and all causes. There have been many studies of morbidity and mortality in patients with chronic bronchitis or emphysema (recent examples are by Cole *et al.*, 1974, and Petty *et al.*, 1976), but

what is relevant in the present context is mortality related to respiratory symptoms and signs in general populations. Higgins and Keller (1970) pointed out that little was known about the prognostic implications of what they called the "less severe but very common manifestations of chronic respiratory disease"; they then described a study of the adult population of the American town of Tecumseh. Here, 2,452 men over 16 years of age were examined in 1959-60, and 1,759 (or 72 per cent) were re-examined about four years later. The number known to have died in the interval was 113 and the deaths were classified according to:- symptoms at the earlier examination; diagnosis then of chronic bronchitis, emphysema or asthma; ventilatory capacity; and certain combinations. The method of mortality analysis, particularly in determining expected numbers of deaths, is not entirely clear. The sign or symptom with the highest SMR (2.5) was shortness of breath: it would appear that 63 deaths had been observed compared with 25 expected. The SMRs for cough and phlegm grade II and for chronic bronchitis were both 1.8, while men with $FEV_{1.0}$ below 2 litres had an SMR of 1.4. As *a priori* arguments had been used, without attempt to make the sub-cohorts mutually exclusive, the usual lack of independence of findings arose and has to be noted.

Kauffmann *et al.* (1975) examined the prognostic value of chronic cough, sputum and spirometry in a ten-year mortality study among 1,487 men working in factories near Paris. Mean indices of lung function, adjusted for age, were worse for those who died than for those who survived, but the differences were small and patterns were not consistent from one age group to another, the youngest, i.e. those aged 30 through 34 years, conforming least well. The "statistical signific-

ance" claimed for the differences lay largely in the numbers of subjects, and provided no grounds for prediction.

Ashley *et al.* (1975) related pulmonary function to ageing, cigarette habit and mortality, as part of the Framingham Study. In two medical examinations, approximately ten years apart, the numbers of men studied were 1,937 and 1,127. It is not clear whether all those examined on the later occasion were part of the cross-section from the former, but the proportion is at best 58 per cent. The only tabular material on mortality provided "standardized univariate logistic risk function coefficients for risk of death in ten years for FVC and FEV_{1.0} per cent in an eighteen year follow-up" but no details are given of the methods. From a figure giving the "*smoothed* (my italics) probability of death in ten years by FVC at [the earlier] examination in those then aged 50-59" (without explanation of the reason for choosing this group) it might appear that there was a dose-response relationship.

This evidence on prognosis in general populations is suggestive but not particularly convincing.

In Cohort "A", where respiratory symptoms and signs had been assessed, dyspnoea and depressed FVC were associated with high Relative Risks of mortality from all causes, 1.49 and 1.53, respectively, but other symptoms and other function measurements had low predictive value. In the same cohort, total mortality was predicted especially well by cigarette smoking (RR = 1.88, with $\chi^2 = 10.18$), and also, but less well, by parenchymal changes on the x-ray (RRs of 1.56 for small

opacities and 1.81 for large opacities), by pleural changes (RRs of 1.80 for calcification and 1.81 for other pleural changes); the Relative Risks quoted in this sentence were higher than for the one respiratory symptom and the one lung function test that had fair predictive value. Accumulated dust exposure was associated with enhanced risk, but only to the extent of $RR = 1.21$.

In Cohort "B", all features of radiographic change predicted excess mortality from all causes (RRs of parenchymal changes: 1.98 for small opacities and 4.43 for large opacities; RRs of pleural changes: 1.87 for un-calcified and 1.62 for calcified; and $RR = 2.21$ for "additional symbols"); so did cigarette smoking ($RR = 1.67$) and comparatively severe dust exposure ($RR = 1.51$).

In all these "comparisons" of effects, it is important to bear in mind their lack of independence, and the different methods by which they have been assessed. However, it seems not unreasonable to infer that respiratory symptoms and lung function changes are not better predictors of excess mortality than radiographic changes, nor than cigarette smoking; asbestos dust exposure by itself does not appear a particularly good predictor of mortality.

14.5 Pneumoconiosis and related conditions

Pneumoconiosis is surely due to retention of dust in the lungs and so death from this cause should be associated with x-ray change. There are other conditions which may well be associated, directly or indirectly, with dust retention, and so should be detectable on the

radiograph, again either directly or indirectly, viz:- respiratory tuberculosis, "other" respiratory diseases and heart diseases.

Pneumoconiosis. The effect of asbestos dust exposure was obvious, but there was no effect of smoking. These findings were clear in the main mortality study, summarized by McDonald and Liddell (1978) and equally so in both cohorts of the present research; further they were confirmed by case-control methods in Cohort "B". Most of the radiographs of men who died from pneumoconiosis showed radiographic change, usually parenchymal, with or without pleural change. "Sensitivity" was found as 77 per cent, i.e. 24 men with changes in 31 deaths. "Specificity", assessed in the controls, was 71 per cent: 22 men without parenchymal change among 31 controls. The small opacities in the radiographs of men who died from pneumoconiosis were nearly always irregular; their profusion was comparatively high, all but four of the 37 readings, i.e. nearly nine-tenths, being of category 1/0 or greater. Large opacities were present only rarely and only when the background small opacities were of profusion at least 2/2.

In view of the causal association with dust exposure, some pneumoconiotic x-ray change was to be expected in every case of death from pneumoconiosis. However, there were seven men who died from this condition, all of whom had been exposed to at least 100 mpcf.y (four of them to more than 300 mpcf.y), in whom no radiographic change was noted. The explanation for this "failure" of the radiological system does not lie in a long interval between x-ray and death; the distribution of intervals was almost identical in those men whose films were

normal and others. However, one or perhaps two of the "failures" might conceivably have had time for a radiological attack as they did not die until 1975 and 1974, having been still at work in November 1966. Three of the seven "failures" had accumulated dust exposures by the time of x-ray of 987 mpcf.y, 1,036 mpcf.y and 2,798 mpcf.y. Although their deaths were attributed to pneumconiosis, it might be that the symptoms were non-specific but that known heavy exposure led to this cause being included at death registration. On the other hand, there may well have been some fibrosis of the lung generated by such large quantities of dust to which the men had been exposed, but the fibrosis was either not radio-opaque or had been missed in the radiographic assessment; three different readers were involved. Another factor that can be eliminated as an excuse for the "failures" is film quality: four of the seven films had been scored "+" and the other three "+/-".

Respiratory tuberculosis. Although this cause of death was common before 1965, much more so at Thetford Mines than at Asbestos, there were no deaths from this disease in Cohort "A" nor in Era 3 of Cohort "B". However, there were 40 deaths from tuberculosis in the earlier Eras of this latter cohort; Relative Risks were high for each type of radiographic change, particularly "large opacities" and "additional symbols". These shadows may have been of the tuberculosis itself, while the other recorded changes may have been indirect manifestations.

The generally accepted view has been that tuberculosis is not related to asbestos exposure, although it is well-known to interact with silica (see, for example, the review by Liddell, 1975c). Table 11.15 shows that men at Thetford Mines had a risk of death from respiratory

tuberculosis twice as high as that at Asbestos, while the Relative Risk associated with heavier dust exposure was rather less (1.64). This might suggest that for this disease, the causative factor lay in the socio-economic environment of Thetford Mines, rather than in the asbestos dose; that dust exposures were heavier there may well have been only coincidental.

"Other" respiratory diseases. Relative Risks of these conditions were very high for men in Cohort "B" with large opacities, un-calcified pleural changes and small opacities; they were also high for "additional symbols", and in men with heavier dust exposures. In Cohort "A", on the other hand, the factors with the highest Relative Risks were depressed MMF and FVC. It may be that the "mixes" of diseases included under this heading were rather different in the two cohorts, because of the different eras in which the deaths occurred, i.e. only after 1967 in Cohort "A", but as far back as 1951 in Cohort "B".

Heart disease. Because of the definition of Cohort "A" that men had been interviewed and tested at least six months and often over two years after the x-ray had been taken, sudden death closely following that event would exclude from this cohort, but not from Cohort "B". Thus, for this cause of death also, different patterns would not be surprising. In Cohort "A", the highest Relative Risk was for dyspnoea; all radiographic features were also associated with enhanced risk, as were dust exposure and cigarette smoking. The lung function measurements showed little association with mortality. In Cohort "B", the most significant Relative Risk was for cigarette smokers, but heavy accumulated dust exposure, small opacities, pleural changes and "add-

itional symbols" were all associated with excess mortality.

Holman (1976) states that: "Numerous epidemiological studies have indicated that cigarette smokers have increased mortality ratios for Coronary Heart Disease (CHD); that is, cigarette smokers show significantly increased death rates compared with non-smokers. The risk incurred by cigarette smoking increased with increasing dosage and, as measured by mortality ratios, is more marked for men in the younger age groups, under age 60, although the absolute increment in death rates experienced by smokers over that of non-smokers continues to increase with increasing age." Her most reliable sources appear to be Hammond and Horn (1958), Doll and Hill (1964), Best (1966), Kahn (1966), Hammond and Garfinkel (1969) and Weir and Dunn (1970). The studies varied in size, from 41 thousand British doctors to 359 thousand US males, in ages at entry, in length of follow-up (three-and-a-half years to ten years) and in categorization of smoking habits. This categorization is not always entirely clear in Holman's Table 3, but the highest category was never less than 20 cigarettes a day. The Relative Risks of death from CHD for those who smoked most, compared with non-smokers, were, for the six studies in the order given above:- 2.41; 1.43; 1.78; 2.00; 1.77; and 1.74. The basic finding that cigarette smokers have increased mortality ratios compared with non-smokers is fully supported by Relative Risks of 1.38 and 1.78, in our two cohorts (Table 11.17).

However, CHD accounts for by no means all the mortality ascribed to diseases of the heart; a substantial proportion of deaths of this nature are in fact secondary to lung disease, and there is likely to

be some mortality in an asbestos-exposed population that is coded on death certification as due to heart disease which has arisen as a consequence of the dust exposure. This is confirmed by the high Relative Risks in both cohorts for men with heavier dust exposure and for each radiographic feature, although the "additional symbols", so prominent in Cohort "B", may be to some extent at least a direct record of heart disease unrelated to dust exposure.

14.6 Neoplasia

Chest cancer is undoubtedly associated with smoking and dust exposure. The illness, once diagnosed, has short duration. Thus, if the interval between x-ray and death is short, the cancer itself might be detected; if the interval is longer, it is possible that there would be signs of dust retention.

Parenchymal changes were seen in about a third of the chest cancer cases in both cohorts, with pleural thickening and calcification in a further eighth; in Cohort "B", one-tenth more showed only "additional symbols". The parenchymal changes were quite different compared with those in pneumoconiosis deaths; there were rather more rounded opacities, profusion was rather lower and there were several cases of "large opacities", mainly poorly-defined, often on a low or even non-existent background of small opacities. In the 118 cases, some radiographic change was seen in 70 (sensitivity 59 per cent); among 118 controls, films were normal for 80 (specificity 68 per cent).

It must be counted a "failure" when the radiograph was assessed as normal despite substantial dust exposure, say greater than 300

mpcf.y. In 62 men who died from chest cancer after exposure to at least this amount of dust, only 36 showed any radiographic change and in only twenty of these cases was the finding of small opacities. Indeed, the proportion of cases whose films showed small opacities was independent of smoking habit and dust exposure (Table 11.12). However, there is insufficient evidence at this stage to answer the question whether cancer of the lung is a complication of asbestosis or an independent reaction to the retention of asbestos dust, i.e. unrelated except by chance to fibrotic reaction.

However, some of what have been called "failures" were due to long intervals between x-ray and death. When this interval was substantial, the proportion of "normals" was considerably higher than when the interval was short (see section 11.3). Nevertheless, there was another form of "failure" of the radiological system when death was not long after the x-ray: a considerable proportion of the radiographic changes that were recorded were of "large opacities", i.e. an apparent recognition of the malignancy itself, but classifying it as though it were pneumoconiotic.

Mesothelioma. Intervals between x-ray and death were either greater than five years (three deaths) or a year or less (the other three deaths). In the former situation, only indirect evidence could be found, because of the very short duration of the disease; the three films were recorded as (1) with pleural calcification (by all six readers for the one case in Cohort "A"); (2) with small opacities of type "p" and profusion 1/0; and (3) normal. In the shorter intervals, it would not have been impossible that the tumour itself was recog-

nized, but the readings were (4) pleural calcification associated with irregular diaphragm; (5) small opacities type "t" of minimal profusion, 0/1; and (6) an "additional symbol" - the only reading that might have been a correct diagnosis of the mesothelioma.

Cancer of oesophagus or stomach is thought to be dust-related but could not be seen directly on a radiograph of the chest; there were, however, pneumoconiotic signs in a substantial proportion of cases. With *other cancers of the gastro-intestinal tract*, the signs were less marked, being weak for cancer of colon or rectum and particularly so for other abdominal cancers.

There is little evidence that *laryngeal cancer* is related to chrysotile exposure, and there were no indications to that effect in this study. There were very few deaths from this cause and all the men had been smokers; there had been too few to provide any measure of statistical confidence in the association with smoking from this study alone, but the main mortality investigation gave clear evidence of a smoking effect.

With *other cancers*, there was little indication of association with radiographic change.

14.7 Other causes of death

There is little reason to believe that the remaining cause groups could be realistically related to asbestos exposure, and so the effects that were observed are surprising and difficult to rationalize. Deaths from strokes appeared to be predictable from depressed FVC, the pres-

ence of large opacities on the radiograph and heavy dust exposure; accidental death from small opacities and smoking. As to "other" causes, higher risks in both cohorts in relation to radiographic changes could only be elucidated by examination cause by specific cause, even although it had been thought that all *relevant* causes had been included in one or other of the groups already discussed.

14.8 Validation of the radiographic classification

This research has provided clear validation of the U/C classification for those diseases which are both asbestos-related and distinguishable on x-ray. There was similar validation for those conditions only indirectly detectable on the radiograph.

The importance of *small irregular opacities* and *pleural changes*, introduced into radiographic classifications for the first time in 1967, requires emphasis. The reason for including these features was that they were frequently seen in the x-ray films of asbestos workers although no need for a classification of them had arisen for those exposed to silica or coalmine dust. Nevertheless, three recent studies have to be mentioned.

Amandus *et al.* (1976) stated that Carilli *et al.* (1973) had demonstrated much more frequent occurrence of "small irregular opacities" in smoking than in non-smoking females. However, the radiographic classification in the earlier study was non-standard, having been devised with the aim of seeing whether two particular readers could identify which subjects were smokers and which not in terms of x-ray appearances. A little later, Theriault *et al.* (1974) claimed to have shown

an association between smoking and small irregular opacities in granite shed workers. Here, a routine chest x-ray film of each of 784 workers had been assessed into the U/C classification (Bohlig *et al.*, 1970); but, unfortunately, only one reader was involved. He found small opacities in 233 films (29.7 per cent), mostly rounded (166 films); the prevalence of irregular small opacities of profusion category 1 or more was 67 of 784 men, or 8.5 per cent. Interpretation of the findings is difficult, but the so-called direct relationships between smoking and both the profusion and type of small irregular opacities appear to be no more than a "confounding" with an effect of age. Finally, it is particularly hard to disentangle the results of Amandus *et al.* (1976), because of oddly selected samples, of smoking and non-smoking coal miners, chosen in terms of *earlier* radiographic assessments, once more by a single reader; in particular, subjects in whom profusion of 0/1 had been read were excluded. In both smokers and non-smokers, just 87 per cent of the selected films had been placed in category 0 of small opacities. Among the 4,479 smokers included in the study, irregular small opacities, with or without rounded opacities, had been seen in 287, or 6.4 per cent; in the 1,687 non-smokers, 59 had had irregular small opacities (3.5 per cent).

Whether any of these findings would have been repeated with other film readers remains a matter of speculation. The findings from the present research were much more positive, and it must be stressed that they are based on the radiological assessments of six readers who had helped to devise the classification they used. Nevertheless, they showed the usual degree of inter-observer variation, and there was some evidence of differences between them in their ability to predict

mortality (see, for example, Table 10.3).

Although only one reader made substantial use of the 0/- category of profusion of small opacities, there was some suggestion that it indicated a truly exceptional normality associated with good prognosis. More attention should be paid to this category; it does not appear to be purely a reflection of youth, nor is it a mask for emphysema which has obscured lung markings.

Instructions on averaging the profusion of small opacities, particularly when those of both types co-exist, have not remained standard with the various classifications. The 1967 notes in the Appendix state that: "As in the case of rounded small opacities, the profusion of the irregular small opacities is based on an averaging over the whole lung and by comparison with the standard films", but ILO (1972, p. 9) has it that: "The category of profusion of both types of small opacities is determined by averaging the profusion in the affected zones", and appears to add confusion by continuing: "When there is marked difference in profusion in different zones of the lung, the zones predominantly affected are the ones over which averaging is made". Although almost immediately there is an exhortation to state the method of averaging in publications using the classification, such a statement seems never to have been made. It is now not possible to determine exactly how averaging was carried out in 1967 during the reading described by Rossiter *et al.* (1972) and used as the basis for the present research. Thus, whether the scoring system described in Table 8.1 was the best that could have been devised cannot be known.

However, it did allow some *grading of the numbers of small opacities*, rounded and irregular combined, in both cohorts. In Cohort "B", the SC scores were placed in three groups:- 0 ("absent"); 1 through 3 ("slight"); and 4 or greater ("positive"). Bearing in mind the method of obtaining SC, the "slight" group had no more than profusion 0/1 in half the lung zones. In Cohort "A", the sums of the 6 SC scores were also placed in three groups:- 0 ("absent"); 1 through 6 ("slight"); and 7 or greater ("positive"). Here, the "slight" group represents even lower profusion averaged over the six readers. The SMRs for all causes of death in the two cohorts were:-

<u>Small opacities</u>	Cohort "A"	Cohort "B"
"Absent"	.78	1.30
"Slight"	.96	2.08
"Positive"	1.32	2.48

Although not of "statistical significance" at a conventional level, the gradient in both cohorts is suggestive. It was maintained for several causes of death, indicating that even the very slight parenchymal changes ("normal" in the *Short* U/C or *ILO* U/C classifications) may have some clinical significance.

Further investigation is required of methods of scoring, as well as of averaging; advice is also needed on how to record *combined profusion* when both rounded and irregular forms exist together. The possibility mentioned by Liddell (1977, p. 94) for each lung zone to be treated separately for purposes of categorization would appear to deserve exploration. Although, when it was first proposed, it was thought unlikely to recommend itself to readers, several experts have since expressed interest in such a procedure. This would probably

require, first, scrutiny of the whole film to aid identification of the changes seen zone by zone; thereafter, it should be possible to record *for each zone as a unit* whether small opacities exist and, if so, of what type(s) (p, q, r; s, t, u) and profusion(s), with a final assessment of how much of each zone is affected *in toto*.

It is also desirable to reduce the "middling tendency" (Morgan *et al.*, 1974) and help might well be given by the use of *standard films on the border-lines* between categories, instead of films representing the mid-points of categories, as at present.

There are, no doubt, other ways of improving the present classification, but change should not be made for one purpose without considering the effects for other purposes. It now appears (Dr. Robert N. Jones, personal communication) that the meeting to be held in Washington in September 1978, to make recommendations to the ILO's meeting of experts in Caracas the following month, is to be concerned mainly with the classification for purposes of compensation. Such purposes are undoubtedly important, but differ for each compensation system, even within one country's administration, depending on the mineral to which the claimants have been exposed; they may differ greatly from one country to another. It was a great strength of the ILO U/C (1971) classification that it could be used for compensation, clinical and epidemiological purposes, with variation only of emphasis. A change of the classification to facilitate its use within compensation schemes that is not compatible with its use in other circumstances, with concern also for historical comparisons, would be a grave error.

14.9 Surveillance of the asbestos worker

Sensitivity and specificity of various tests which might be used for surveillance of workers are, as always, conflicting aims. Smoking, dust exposure, some function tests, respiratory symptoms, early radiographic changes can all be made sensitive, but in certain conditions it would appear that radiographic changes are the most specific in relation to the forecasting of mortality in asbestos-exposed populations. There follows an example of the way in which these measures of a test vary with the level at which a decision is taken: it deals with small irregular opacities in predicting death from pneumoconiosis. Using profusion of category 0/1 as the cut-off point yielded sensitivity 64.5 per cent and specificity 80.6 per cent, and there would have been 714 false positives among a total of 734, or 97.3 per cent. However, with 1/0 as cut-off, sensitivity was reduced to 58.1 per cent, while specificity increased considerably to 96.8 per cent, and the proportion of false positives was reduced to 95.4 per cent.

Little is yet known about progression of radiographic appearances while workers are still employed or after withdrawal from exposure, when consideration is concentrated on the problems of prognosis. Serial assessments are required on radiographs and of symptoms, particularly breathlessness, perhaps assessed by a simple standardized exercise test to replace the reliance on answers to a questionnaire. Study should also be made of how the reliability of predicting mortality is changed by variation in the length of the study interval.

Specific recommendations would be to extend the tracing of men in Cohort "A" for several more years, perhaps in the first place to the

end of 1978; by this time there will have been substantially more deaths and it should be possible to make more reliable statements on the relative importance of radiological and other signs and symptoms, particularly if there have been enough deaths to justify case-control studies, or other *a posteriori* methods. Further, there were 277 men in this cohort who were subjected in 1974 to a second set of measurements, including chest x-ray. Follow-up of these men for a rather longer period - to allow adequate mortality for investigation - might cast light on the problems.

Further possibilities arise in another group of men, those in the "radiographic progression cohort" described in section 4.9. Although they numbered only 283, and almost all were still alive at the end of 1975, in a few years there should have been sufficient mortality to justify detailed study. One advantage of this group is that x-ray films spanning an average of twenty years have already been assessed by a group of experienced readers into the ILO U/C (1971) classification by two methods, independent randomized reading and side-by-side reading, the latter with certain scales of abnormality elaborated four-fold beyond even the twelve points of the complete classification of profusion in the current international classification.

14.10 Other possible developments

The recent (U/C, 1968) classification of the pneumoconioses has been almost completely justified in its ability, when used by the six readers who formed the McGill University panel, to predict mortality from asbestos-related disease and even from other causes. That is not to say that sensitivity and specificity were perfect; they were far

from that ideal, but very much higher than in studies of the earlier (ILO, Geneva, 1958) classification in relation to the mortality of coal miners. Nor is it to be thought that the present, ILO U/C (1971), classification is itself ideal. However, the principal need is to build from this essentially valid system.

In the first place, the important questions concern generalizability: can other readers do as well, or better, than the six whose assessments were used in this research? can their reading be improved for use in the prediction of mortality, either generally or by bringing the less successful up to the levels of the more successful?

In our own cohorts, some of these questions could be answered as follows:-

1. In Cohort "A", two hundred or so men of those originally selected for clinical examination but who were not included because of death, illness, refusal, etc., should be incorporated.
2. The date on which each x-ray was taken should be ascertained, so that information could be gleaned on asbestos exposure to that point and afterwards, particularly for those men who continued employment after November 1966.
3. The study intervals should be divided into several periods, short to start with and then of increasing length, in order to learn more about the effects of length of follow-up on

prediction of mortality. If the follow-up is too short, not only will there be few deaths but there would be little evidence to assist in surveillance. When the period of follow-up is long, there will be many deaths, but only indirect effects are likely to be apparent on the x-ray.

4. Work histories should be reviewed, probably in case-control studies, to reduce the workload substantially; such studies could be extended to as many cause groups as might be considered of interest.

5. The radiographs of all men included in the case-control studies just mentioned should be re-examined by the same six readers, still working independently, and, more importantly, by other readers, to allow generalization. In this regard, it would be essential to follow the principles enumerated by the Workshop on the Chest Roentgenogram as an Epidemiologic Tool (Weill and Jones, 1975) by having at least three readers, working independently and "blind" to the provenance of the films, which should include some of unexposed workers; possibilities of repeat reading should also be examined.

6. Purposive study should be made of films which showed abnormality not "justifiable" by the provenance of the film. E.g. what are the appearances recorded as "large opacities" which arose in lung cancer, stroke, etc.? Is there any way that stroke, for example, could possibly be predicted from

x-ray?

It might be argued that a radiological classification which has been so well validated in chrysotile miners and millers would not require further study where both radiographic and health effects are known to be much more dramatic. However, it would seem important to extend the questions, asking whether the system works as well in populations exposed to other fibres, either chrysotile in the manufacturing processes, or amphibole in production or manufacture, or in mixed situations.

Postscript

ORIGINALITY ; IMPORTANCE ;
RESPONSIBILITIES ;
ACKNOWLEDGEMENTS

My interests in relationships between radiology and mortality arose while I was developing the NCB elaboration of the profusion of small opacities and studying the morbidity and mortality of coal miners - remaining disappointed that the prediction of mortality from x-ray findings among the miners of the Rhondda Fach had been so poor. In mid-1976, when Professor McDonald's team reviewed gaps in epidemiological knowledge, the research described in this thesis became feasible: the question that had intrigued me for so long had also been posed by Dr. George Wright, chairman of the Scientific Committee of the Institute of Occupational and Environmental Health; appropriate information could be obtained from the population already under study in Quebec; and I could take day-to-day responsibility for the project.

There was never any doubt about the importance of the project, but the recent confirmation from the 1977 Johannesburg Asbestos Symposium was particularly encouraging. The research has substantially validated the current international radiological classification, but generalization is still required. Some light has been cast on the use of the chest x-ray in the surveillance of the asbestos worker, but here too further research is needed.

The "buff card" register of employees was initiated by Mr. Charles Rossiter, of the MRC Pneumoconiosis Unit, during secondment to McGill University, and he and Dr. Graham Gibbs devised means for calculating the various indices of exposure. The tracing of subjects and, almost as difficult, the ascertainment of causes of death were carried out under the supervision of Professor Alison McDonald; credit for the very few losses and the excellent standard of linkage is due first to her, and also to her two devoted colleagues, Mesdames

Beauchemin and Proulx, in the Eastern Townships. Most of the tracing to the end of 1975 had been completed by the time the present research was under way, but some was still in hand, while men not in the "main mortality cohort" had to be traced and causes of death found; these tasks were completed by the same team, to whom I am extremely grateful.

Although the radiological studies reported by Mr. Rossiter and his colleagues had been largely completed before I started work at McGill University, the 42 thousand readings had been the first major use of the NCB elaboration outside the National Coal Board itself. Mr. Rossiter's contributions, not only of the statistical nature reflected in his publications, but also, and perhaps more important in the present context, of data processing, were quite invaluable. I also gained greatly from discussions with all six film readers, particularly during the project reported by Dr. Gail Eyssen; especial thanks are due to Dr. John C. Gilson, CBE, FRCP, formerly Director of the MRC Pneumoconiosis Unit, who has been a source of great stimulation over many years.

Because so many changes had become necessary for the main mortality investigation, it was decided in 1975 to devise a new system of data processing, rather than attempt to up-date files and programs that had already been extensively patched. The many necessary programs for this new, more flexible, system were written to my specifications by Mr. Mario Rodrigues, who also applied them conscientiously to the several vast bodies of data, requiring many iterations before we could consider the data files to be truly "clean". It is a pleasure to record the gratitude of the entire team to Mr. Rodrigues for this work, which led to a particularly meritorious M.Sc. At all stages, the problems of record linkage have been great; my intimate knowledge of the procedures and practices adopted in the main mortality enquiry made it possible to apply the same standards in the present research.

My concern with methods of cohort analysis has been intensive since shortly before the meeting of statisticians at McGill University

in June 1974, through the presentation to the Royal Statistical Society in June 1977, to the present. My thanks are due to many statistical colleagues who have helped, a few "formally" in 1974, but most quite informally over the years. They include: Professor Peter Armitage; Mr. Geoffrey Berry; Professor David Cox; Dr. Gerald Draper; Professor Phil Enterline; Dr. Gail Eyssen; Professor Michael Healy; Dr. David Hill; Dr. Larry Muenz; Dr. David Oakes; Dr. Peter Oldham; Mr. Charles Rossiter; Dr. Peter Smith; Mrs. Joyce Snell; Dr. "Babs" Solari; and Dr. Duncan Thomas.

Without access to the current findings of the main mortality investigations, this thesis would have been much less satisfactory. I supervised Mr. Rodrigues, in 1976-77, in the analysis of deaths to the end of 1973, and thereafter in the up-date and re-analysis to end-1975. However, in interpretation, my contribution has been essentially co-operative. In particular, the recent review paper (McDonald and Liddell, 1978) was prepared principally to show how results had been essentially unchanged since the outset, and frequent reference to it should not be construed as suggesting that I had any role other than that indicated here. However, this paper has provided many useful up-to-date results and has already been presented, so that it should appear in print before "McDonald *et al.* (1979)", which is still in preparation. Nevertheless, it is important to emphasize that the results of our main mortality enquiries are the fruits of team effort.

I wish to thank all members of the research team at McGill University, i.e. Professor Margaret Becklake; Dr. Gail Eyssen; Dr. Graham Gibbs; Professors Alison and Corbett McDonald; and Dr. Duncan Thomas, for permission to use data and for willingly-given advice. Data processing and other computing, all to my specifications, were entrusted to Mr. Rodrigues, and I owe him an enormous debt of gratitude which I am very pleased to acknowledge; I also thank Ms. Marielle Olivier who assisted from time to time. Thanks are also due to the Institute of Occupational and Environmental Health for their financial support to Professor McDonald for this research.

Two others deserve especial mention. The first is Mrs. Ann Yaxley, who has assisted cheerfully, often well "beyond the call of duty". It would be impossible to describe all the ways in which she has helped, and I am enormously grateful to her.

Finally, Professor Corbett McDonald, friend and colleague for many years, has been an inspiring supervisor. He has criticized constructively from his encyclopaedic knowledge of the subject, yet without interfering, and has shown me how to extend my reading much more widely than would otherwise have been possible. He is the Principal Investigator of "the only really grand study" of which my project has formed but a part, and it was only with his permission and under his aegis that I was able to use the data and conduct this research. The gratitude I owe him is clearly unrepayable.

In conclusion, I must take full responsibility for any errors in this thesis (in particular for those concerning taped information on certain symptoms), and for all opinions expressed.

B I B L I O G R A P H Y

- AMANDUS, H E, LAPP, N L, JACOBSON, G and REGER, R B (1976)
Significance of irregular small opacities in radiographs of
coalminers in the USA
Brit. J. industr. Med. 33: 13
- ARMITAGE, P (1971)
Statistical methods in medical research
Oxford and Edinburgh: Blackwell
- ARMITAGE, P (1977)
In discussion of Liddell, McDonald and Thomas (1977), p. 488
- ASBESTOS (1970)
The asbestos factbook
Willow Grove, Pennsylvania: Asbestos magazine
- ASBESTOS TEXTILE INSTITUTE, AIR HYGIENE AND MANUFACTURING COMMITTEE
(1963)
*Asbestos Textile Institute method for determining asbestos dust
concentration approved by the Asbestos Textile Institute*
Pompton Lakes, NJ: Asbestos Textile Institute
- ASHLEY, F, KANNEL, W B, SORLIE, P D and MASSON, R (1975)
Pulmonary function: relation to aging, cigarette habit and
mortality
Ann. internal Med. 82: 739
- AYER, H E, LYNCH, J R, and FANNEY, J H (1965)
A comparison of impinger and membrane filter techniques for
evaluating air samples in asbestos plants
Ann. New York Acad. Sci. 132: 274

BARIS, Y I, ARTVINLI, M and ALTAY SAHIN, A (1978)

Environmental mesothelioma in Turkey

Ann. New York Acad. Sci. (in press)

BECKLAKE, M R (1976)

Asbestos-related diseases of the lung and other organs: their epidemiology and implications for clinical practice

Amer. Rev. Resp. Disease 114: 187

BECKLAKE, M R, FOURNIER-MASSEY, G, McDONALD, J C, SIEMIATYCKI, J and ROSSITER, C E (1970)

Lung function in relation to chest radiographic changes in Quebec asbestos workers

Bull. Physio-path. Resp. 6: 637

BECKLAKE, M R, FOURNIER-MASSEY, G, ROSSITER, C E and McDONALD, J C (1972)

Lung function in chrysotile asbestos mine and mill workers in Quebec

Arch. environ. Health 24: 401

BECKLAKE, M R, LIDDELL, F D K, MANFREDA, J and McDONALD, J C (1978)

Radiological changes after withdrawal from asbestos exposure

Brit. J. indust. Med. (in press)

BERRY, G (1970)

Parametric analysis of disease incidences in multiway tables

Biometrics 26: 572

BERRY, G (1977a)

In discussion of Liddell, McDonald and Thomas (1977), p. 485

BERRY, G (1977b)

Is there a dose-effect relation for cancers related to occupational exposure to asbestos fibres? Is a zero-effect threshold value meaningful?

Chambre Syndicale de l'Amiante et le Syndicat de l'Amiante-Ciment: 43

BEST, E W R (1966)

A Canadian study of smoking and health

Ottawa: Department of National Health and Welfare

BILLIEWICZ, W Z, KEMSLEY, W F F and THOMSON, A M (1962)

Indices of adiposity

Brit. J. prev. soc. Med. 16: 183

BOGOVSKI, P, GILSON, J C, TIMBRELL, V and WAGNER, J C (Eds) (1973)

Biological Effects of Asbestos

Lyon: IARC

BOHLIG, H (1965)

Radiological classification of pulmonary asbestosis

Ann. New York Acad. Sci. 132: 338

BOHLIG, H, BRISTOL, L J, CARTIER, P H, FELSON, B, GILSON, J C,

GRAINGER, T R, JACOBSON, G, KIVILUOTO, R, LAINHART, W S,

McDONALD, J C, PENDERGRASS, E P, ROSSITER, C E, SELIKOFF, I J,

SLUIS-CREMER, G K and WRIGHT, G W (1970)

UICC/Cincinnati classification of the radiographic appearances of pneumoconioses

Chest 58: 57

BONSER, G M, FAULDS, J S and STEWART, M J (1955)

Occupational cancer of the urinary bladder in dyestuffs

operatives and of the lungs in asbestos textile workers and iron-ore miners

Amer. J. clin. Path. 25: 126

BRAUN, D C and TRUAN, T D (1958)

An epidemiological study of lung cancer in asbestos miners
A.M.A. Arch. industr. Health 17: 634

CARILLI, A D, KOTZEN, L M and FISCHER, M L (1973)

The chest roentgenogram in smoking females
Amer. Rev. of Resp. Disease 107: 133

CASE, R A M and LEA, A J (1955)

Mustard gas poisoning, chronic bronchitis and lung cancer
Brit. J. prev. soc. Med. 9: 62

CLIFTON, R A (1974)

Asbestos In: *1974 Bureau of Mines Minerals Yearbook*
Washington: US Government Printing Office

COCHRAN, W G (1954)

Some methods for strengthening the common χ^2 tests
Biometrics 10: 417

COCHRAN, W G (1965)

The planning of observational studies of human populations,
with discussion
J. Roy. Statist. Soc. A 128: 234

COCHRANE, A L (1973)

Relation between radiographic categories of coalworkers'
pneumoconiosis and expectation of life
Brit. Med. J. 2: 532

COCHRANE, A L, CARPENTER, R G, MOORE, F and THOMAS, J (1964)

The mortality of miners and ex-miners in the Rhondda Fach
Brit. J. industr. Med. 21: 38

COCHRANE, A L, DAVIES, I and FLETCHER, C M (1951)

"Entente radiologique": a step towards international agreement
on the classification of radiographs in pneumoconiosis

Brit. J. industr. Med. 8: 244

COLE, T J, GILSON, J C and OLSEN, H C (1974)

Bronchitis, smoking and obesity in an English and a Danish town

Bull. Physio-path. Resp. 10: 657

COOKE, W E (1924)

Brit. Med. J. 2: 147

COX, D R (1972)

Regression models and life tables

J. Roy. Statist. Soc. B 34: 187

DAGBERT, M (1976)

*Etude de corrélation des mesures d'empoussièrage dans l'industrie
de l'amiante*

Document 5. Quebec: Comité d'étude sur la salubrité dans
l'industrie de l'amiante (Président: René Beaudry, j.c.p.)

DIEM, K (Ed) (1962)

Documenta Geigy: Scientific Tables, 6th ed.

Montreal: Geigy Pharmaceuticals

DOLL, R S (1955)

Mortality from lung cancer in asbestos workers

Brit. J. industr. Med. 12: 81

DOLL, R (1964)

Retrospective and prospective studies in WITTS, L J (Ed) (1964)

Medical surveys and clinical trials, 2nd ed.

London: Oxford University Press

DOLL, R and HILL, A B (1964)

Mortality in relation to smoking: 10 years observations of
British doctors (Part 1)

Brit. Med. J. 1: 1399

DREESSEN, W C, DALLAVALLE, J M, EDWARDS, T I, MILLER J W,

SAYERS, R R, EASOM, H F and TRICE, M F (1938)

A study of asbestosis in the asbestos textile industry

Public Health Bull. 241 Washington: US Public Health Service

ECK, M and HANAUT, A (1944)

Arch. Mal. Prof. 6: 74 cited by Van Mechelen and McLaughlin (1962)

ELMES, P C and SIMPSON, M J C (1971)

Insulation workers in Belfast 3. Mortality 1940-66

Brit. J. industr. Med. 28: 226

ELMES, P C and SIMPSON, M J C (1977)

Insulation workers in Belfast: a further study of mortality due
to asbestos exposure (1940-75)

Brit. J. industr. Med. 34: 174

ELWOOD, P C and COCHRANE, A L (1964)

A follow-up study of workers from an asbestos factory

Brit. J. industr. Med. 21: 304

ENTERLINE, P E (1976)

Pitfalls in epidemiological research: an examination of the
asbestos literature

J. occup. Med. 18: 150

ENTERLINE, P E (1978)

Epidemiological methods for the establishment of dose-response
relationships in asbestos-dust-related diseases

In: Glen (1978), pp. 39-41

ENTERLINE, P E, DECOUFLE, P and HENDERSON, V (1972a)

An epidemiological study of respiratory cancer among retired asbestos workers to establish standards for occupational exposures

Presented at the Annual Meeting of the American Academy of Occupational Medicine, 9 February, 1972

ENTERLINE, P E, DECOUFLE, P and HENDERSON, V (1972b)

Mortality in relation to occupational exposure in the asbestos industry

J. occup. Med. 14: 897

ENTERLINE, P E, DECOUFLE, P and HENDERSON, V (1973)

Respiratory cancer in relation to occupational exposures among retired asbestos workers

Brit. J. industr. Med. 30: 162

ENTERLINE, P E and HENDERSON V (1973)

Type of asbestos and respiratory cancer in the asbestos industry
Arch. environ. Health 27: 312

EYSEN, G E (1975)

Methods of assessing radiographic progression in the pneumoconioses

Ph.D. thesis, McGill University

EYSEN, G E and LIDDELL, F D K (1974)

Lung cancer mortality in asbestos workers: an approach through multiple controls

In McDonald et al. (1974)

FAY, J W J and ASHFORD, J R (1964)

Environmental exposure of British coal miners
Arch. environ. Health 9: 144

FAY, J W J and RAE, S (1959)

The Pneumoconiosis Field Research of the National Coal Board
Ann. occup. Hygiene 1: 149

FLETCHER, C M, MANN, K J, DAVIES, I, COCHRANE, A L, GILSON, J C
and HUGH-JONES, P (1949)

J. Fac. Radiol. Lond. 1: 40

FOX, A J (1977)

In discussion of Liddell, McDonald and Thomas (1977), pp.487-488

FOX, A J and COLLIER, P F (1977)

Low mortality rates in industrial cohort studies due to selection
for work and survival in the industry
Brit. J. prev. soc. Med. 30: 225

FRIEDRICHSEN, G W S (1963)

in *The Concise Oxford Dictionary*, 5th ed., 1964, reprinted 1974
London: Oxford University Press

GAFAFER, W M (Ed) (1964)

Occupational Diseases: a guide to their recognition
Washington: Public Health Service, US Department of Health,
Education and Welfare

GARDNER, L V, MIDDELTON, E L and ORENSTEIN, A J (1930)

Report of the International Conference on Silicosis, Johannesburg,
1930
ILO: Geneva, p. 88

GAZE, R (1965)

The physical and molecular structure of asbestos
Ann. New York Acad. Sci. 132: 23

GHEZZI, I, ARESINI, G and VIGLIANI, E C (1972)

The risk of asbestosis in a chrysotile asbestos mine
Medna Lav. 63: 189

GIBBS, G W and DuTOIT, R S T (1978)

Environmental considerations in surveillance of asbestos miners
and millers
Ann. New York Acad. Sci. (in press)

GIBBS, G W and LACHANCE, M (1972)

Dust exposure in the chrysotile asbestos mines and mills of Quebec
Arch. environ. Health 24: 189

GIBBS, G W and LACHANCE, M (1974)

Dust-fiber relationships in the Quebec chrysotile industry
Arch. environ. Health 28: 69

GILSON, J C (1965)

Man and asbestos
Ann. New York Acad. Sci. 132: 9

GILSON, J C (1973)

Progress in epidemiology
In Bogovski et al. (1973), p. 5

GLEN, H W (Ed) (1978)

*Proceedings of Asbestos Symposium, Johannesburg, South Africa,
3rd - 7th October, 1977*
Randburg: National Institute for Metallurgy

GROSS, P (1974)

Is short-fibered asbestos dust a biological hazard?
Arch. environ. Health 29: 115

HAMMOND, C E and GARFINKEL, L (1969)

Coronary heart disease, stroke and aortic aneurysm: factors
in the etiology

Arch. environ. Health 19: 167

HAMMOND, E C and HORN, D (1958)

Smoking and death rates: report on forty-four months of following
up 187,783 men

J. Amer. Med. Assoc. 166: 1159-1172; 1294-1308

HARRIES, P G (1971)

*The effects and control of diseases associated with exposure
to asbestos in Devonport dockyard*

Report CRWP 1/71. Gosport: Institute of Naval Medicine

HENDRY, N W (1965)

The geology, occurrences and major uses of asbestos

Ann. New York Acad. Sci. 132: 12

HIGGINS, M W and KELLER, J B (1970)

Predictors of mortality in the adult population of Tecumseh

Arch. environ. Health 21: 418

HILL, I D (1972)

Computing man years at risk

Brit. J. prev. soc. Med. 26: 132

HOLMAN, P B (Ed) (1976)

The health consequences of smoking

Atlanta: Centre for Disease Control, US Department of Health,
Education and Welfare

HOWARD, S, KINLEN, L J, LEWINSOHN, H C, PETO, J and DOLL, R (1975)

A mortality study among workers in an English asbestos factory

Presented at the XVIII International Congress on International
Health, Brighton, 16 September 1975.

HUGHES, J, WAGGENSPACK, C and WEILL, H (1978)

Mortality study of workers engaged in manufacture of asbestos-cement products (abstract)

Amer. Rev. Resp. Disease 117: Number 4, Part 2, p. 242

HUNTER, D (1975)

The Diseases of Occupations, 5th Ed.

London: English Universities Press

ILO (1953)

Third international conference of experts on pneumoconiosis
(Sydney, 1950)

Geneva: ILO

ILO (1959)

Meeting of experts on the international classification of radiographs of the pneumoconioses

Occup. Safety and Health 9: no. 2

ILO (1970)

International classification of the radiographs of pneumoconioses
(revised 1968)

Occup. Safety and Health Series no. 22 Geneva: ILO

ILO (1972)

ILO U/C international classification of radiographs of the pneumoconioses, 1971

Occup. Safety and Health Series no. 22 (revised) Geneva: ILO

INTERNATIONAL LABOUR OFFICE *see* ILO

IRVINE, - (1934)

Cited by Van Mechelen and McLaughlin (1962), pp. 238-239

IRWIG, L (1978)

A study of variations in the radiological assessment of pneumoconiosis

In: Glen (1978), pp. 139-143

JACOBSEN, M (1976)

Dust exposure, lung diseases and coalminers' mortality

Ph.D. thesis, University of Edinburgh

JACOBSON, G and GILSON, J C (1972)

Present status of the UICC/Cincinnati classification of radiographic appearances of the pneumoconioses: report of meeting held at Pneumoconiosis Research Unit, Cardiff, Wales, April 13-15, 1971

Ann. New York Acad. Sci. 200: 552

JACOBSON, G and LAINHART, W S (Eds) (1972)

ILO U/C 1971 international classification of radiographs of the pneumoconioses

Med. Radiogr. Photogr. 48: 67

JONES, J S P, POOLEY, F D and SMITH, P G (1976)

Factory populations exposed to crocidolite asbestos - a continuing survey

IARC Scientific Publications no. 13, INSERM, 1976 52: 117

KAHN, H A (1966)

The Dorn Study of smoking and mortality among US veterans: report on 8½ years of observation

In: HAENSZEL, W (Ed) (1966) Epidemiological Approaches to the Study of Cancer and Other Chronic Diseases National Cancer

Institute Monograph 19: 1-125 Bethesda: US Public Health Service

KAUFFMANN, F, BRILLE, D and LELLOUCH, J (1975)

Evaluation de la valeur pronostique de la toux, de l'expectoration chroniques et de valeurs spiromographiques par l'étude de la mortalité chez 1,487 hommes au travail en 1960-1961.

Bull. Physio-path. Resp. 11: 45

KEAL, E E (1960)

Asbestosis and abdominal neoplasms

Lancet 2: 1211

KEATINGE, G F (1973)

Review of Ghezzi *et al.* (1972)

Abstracts on Hygiene (1973) no. 1371

KLEINFELD, M, MESSITE, J and KOOYMAN, O (1967)

Mortality experience in a group of asbestos workers

Arch. environ. Health 15: 177

KLEINFELD, M, MESSITE, J, KOOYMAN, O and ZAKI, M H (1967)

Mortality among talc miners and millers in New York State

Arch. environ. Health 14: 663

KNOX, J F, DOLL, R S and HILL, I D (1965)

Cohort analysis of changes in incidence of bronchial carcinoma in a textile asbestos factory

Ann. New York Acad. Sci. 132: 526

KNOX, J F, HOLMES, S, DOLL, R and HILL, I D (1968)

Mortality from lung cancer and other causes among workers in an asbestos textile factory

Brit. J. industr. Med. 25: 293

KOGAN, F M, GUSEL'NIKOVA, N A and GULEVSKAYA, M R (1972)

The cancer mortality rate among workers in the asbestos industry of the Urals

Gig. Sanit. 37: 29

KOGAN, F M, TROITSKY, S K and GULEVSKAYA, M R (1966)
On the carcinogenic effect of asbestos dust
Gigiena Truda i Professional'nye Zabolevaniya 8: 28

LANCET (1977)
Asbestos (Editorial)
Lancet, 10 December 1977, p. 1211

LEE, P D (1966)
Periodic X-ray Scheme: computer processing
Cannock: National Coal Board Computing Services

LEWINSOHN, H C (1977)
Asbestosis - a diagnostic dilemma
J. occup. Med. 19: 607

LEXIS, W (1875)
Einleitung in die Theorie der Bevölkerungs Statistik
Strasbourg: Trulner Cited in: WILSON, A and REES, P (1976)
Spatial demography: some comments *Statistician* 25: 59

LIDDELL, F D K (1960)
The measurement of occupational mortality
Brit. J. industr. Med. 17: 228

LIDDELL, F D K (1961)
The effect of film quality on reading radiographs
Brit. J. industr. Med. 18: 165

LIDDELL, F D K (1963)
An experiment in film reading
Brit. J. industr. Med. 20: 300

LIDDELL, F D K (1972)
Validation of classifications of pneumoconiosis
Ann. New York Acad. Sci. 200: 527

LIDDELL, F D K (1974)

Methods of analysing mortality in relation to occupational exposure

Report of a symposium, 10-11 June, 1974 at McGill University
(privately circulated)

LIDDELL, F D K (1975a)

The Ontario chest x-ray classification

Report to the Royal Commission on the Health and Safety of
Workers in Mines (Ontario) (privately circulated)

LIDDELL, F D K (1975b)

Occupational mortality in relation to exposure

Arch. environ. Health 30: 266

LIDDELL, F D K (1975c)

Health and safety in mines

Report to the Royal Commission on the Health and Safety of
Workers in Mines (Ontario) (privately circulated)

LIDDELL, F D K (1977)

Radiological assessment of small pneumoconiotic opacities

Brit. J. industr. Med. 34: 85

LIDDELL, F D K, EYSSEN, G E, THOMAS, D C and McDONALD, J C (1977)

Radiological changes over 20 years in relation to chrysotile
exposure in Quebec

In: WALTON, W H (Ed) (1977), *Inhaled Particles IV*, Pergamon
Press: Oxford and New York, pp. 799-812

LIDDELL, F D K and FINCH, D J (1958)

Syllables of recorded time

Incorp. Statistician 8: no. 3

LIDDELL, F D K and LINDARS, D C (1969)

An elaboration of the ILO classification of simple pneumoconiosis

Brit. J. industr. Med. 26: 89

LIDDELL, F D K, McDONALD, J C and THOMAS, D C (1977)

Methods of cohort analysis: appraisal by application to
asbestos mining

J. Roy. Statist. Soc. A 140: 469

LIDDELL, F D K and MAY, J D (1966)

Assessing the radiological progression of simple pneumoconiosis

Med. Res. Mem. 4 London: National Coal Board

LINCOLN, B (1972)

Mining and milling (of asbestos)

Review 1972/2 Basle: Ciba-Geigy, pp. 9-13

McDONALD, A D and McDONALD, J C (1978)

Mesothelioma after crocidolite exposure during gas mask
manufacture

Environ. Res. (in press)

McDONALD, J C (1973)

Cancer in chrysotile mines and mills

In: Bogovski et al. (1973), pp. 189-194.

McDONALD, J C (1975)

Health risks in asbestos production

Presented at the International Conference on Lung Diseases,
Montreal, May 18th, 1975.

McDONALD, J C, BECKLAKE, M R, FOURNIER-MASSEY, G and ROSSITER, C E
(1972)

Respiratory symptoms in chrysotile asbestos mine and mill workers
of Quebec

Arch. environ. Health 24: 358

- McDONALD, J C, BECKLAKE, M R, GIBBS, G W, McDONALD, A D and
ROSSITER, C E (1974)
The health of chrysotile asbestos mine and mill workers of
Quebec
Arch. environ. Health 28: 61
- McDONALD, J C, GIBBS, G W, MANFREDA, J and WHITE, F M M (1972)
Storage as a factor in disease due to mineral dusts
*In: LEE, D H K and KOTIN, P (Eds) (1972) Multiple factors in
the causation of environmentally induced disease* New York and
London: Academic Press, pp. 186-201
- McDONALD, J C and LIDDELL, F D K (1978)
Mortality in Canadian miners and millers exposed to chrysotile
Ann. New York Acad. Sci. (in press)
- McDONALD, J C, LIDDELL, F D K, GIBBS, G W, EYSEN, G E and
McDONALD, A D (1979)
Dust exposure and mortality in chrysotile mining, 1910-75
Brit. J. industr. Med. (in preparation)
- McDONALD, J C and McDONALD, A D (1977)
Epidemiology of mesothelioma from estimated incidence
Preventive Med. 6: 426
- McDONALD, J C, McDONALD, A D, GIBBS, G W, SIEMIATYCKI, J and
ROSSITER, C E (1971)
Mortality in the chrysotile asbestos mines and mills of Quebec
Arch. environ. Health 22: 677
- McDONALD, J C, ROSSITER, C E, EYSEN, G and McDONALD, A D (1973)
Mortality in the chrysotile producing industry of Quebec: a
progress report
*In: Proceedings of the IVth International Pneumoconiosis Confer-
ence, Bucharest, 1971* Bucharest: Apimondia, pp. 234-237

McKINLAY, S M (1975)

The effect of bias on estimators of relative risk for pair-matched and stratified samples

J. Amer. Statist. Assoc. 70: 859

McKINLAY, S M (1977)

Pair-matching - a reappraisal of a popular technique

Biometrics 33: 725

McMAHON, B, PUGH, T F and IPSEN, J (1960)

The strategy of epidemiology

Chapter 4 in *Epidemiologic Methods*, pp. 32-50 Boston: Little, Brown

McNEMAR, Q (1947)

Note on the sampling error of the differences between correlated proportions or percentages

Psychometrika 12: 153

McVITTIE, J C (1965)

Asbestosis in Great Britain

Ann. New York Acad. Sci. 132: 128

MANCUSO, T F and COULTER, E J (1963)

Methodology in industrial health studies: the cohort approach, with special reference to an asbestos company

Arch. environ. Health 6: 210

MANCUSO, T F and EL ATTAR, A (1967)

Mortality pattern in a cohort of asbestos workers

J. occup. Med. 9: 147

MARTISCHNIG, K M, NEWELL, D J, BARNSLEY, W C, COWAN, W K,

FEINMANN, E L and OLIVER, E (1977)

Unsuspected exposure to asbestos and bronchogenic carcinoma

Brit. Med. J. 1: 746

MEAD, E D (1966)

Periodic X-ray Scheme:documentation for "frozen" 1401 system
London: National Coal Board Medical Statistics Branch

MEDICAL RESEARCH COUNCIL *see* MRC

MEREWETHER, E R A and PRICE, C W (1930)

Report on effects of asbestos dust in the lungs and dust suppression in the asbestos industry
London: HMSO

MESSEL, M J (1978)

The Quebec asbestos mining industry at the crossroads
Quebec: QAMA

MEURMAN, L O, KIVILUOTO, R and HAKAMA, M (1974)

Mortality and morbidity among the working population of anthophyllite asbestos miners in Finland
Brit. J. industr. Med. 31: 105

MIEKLEJOHN, A (1960)

The origin of the term pneumonokoniosis
Brit. J. industr. Med. 17: 155

MIETTINEN, O S (1969)

Individual matching with multiple controls in the case of all-or-none response
Biometrics 25: 339

MIETTINEN, O S (1970)

Matching and design efficiency in retrospective studies
J. Epidemiology 91: 111

MILLER, R G (1966)

Simultaneous statistical inference
New York: McGraw-Hill

MORGAN, W K C (1975)

The deposition and clearance of dust from the lungs
In: Morgan and Seaton (1975), pp. 20-28

MORGAN, W K C, PETERSEN, M R and REGER, R D (1974)

The "middling" tendency
Arch. environ. Health 29: 334

MORGAN, W K C and SEATON, A (Eds) (1975)

Occupational lung diseases
Philadelphia, London and Toronto: Saunders

MRC COMMITTEE ON RESEARCH INTO CHRONIC BRONCHITIS (1966)

Instructions for the use of the questionnaire on respiratory symptoms (1966)
Dawlish: MRC

MUIR, D F C (1972)

Clinical aspects of inhaled particles, I
London: Heinemann

MURRAY, H M (1907)

Report of the Departmental Committee on Compensation for Industrial Diseases: Minutes of Evidence, Appendices and Index
London: HMSO, p. 127

NELDER, J A (1975)

GLIM (Generalized Linear Interactive Modelling Program)
Appl. Statist. 24: 259

NEWHOUSE, M L (1973a)

Asbestos in the work place and the community
Ann. occup. Hygiene 16: 97

NEWHOUSE, M L (1973b)

Cancer among workers in the asbestos textile industry
In: Bogovski et al. (1973), pp. 203-208

NICHOLSON, W (1976)

Evidence presented 27 February 1976, to the Comité d'étude
sur la salubrité dans l'industrie de l'amiante (Québec),
Président: René Beaudry, j.c.p.

NICHOLSON, W J, LILIS, R and SELIKOFF, I J (1978)

Long-term mortality experience of chrysotile miners and millers
in Thetford Mines, Quebec
Ann. New York Acad. Sci. (in press)

NIE, N H, BENT D H and HULL, C H (1970)

Statistical package for the social sciences
New York: McGraw-Hill

NURMINEN, M (1972)

A study of the mortality of workers in an anthophyllite factory
in Finland
Work-Environ.-Health 9: 112

PETO, J (1978)

The hygiene standard for chrysotile asbestos
Lancet 1: 484

PETO, J, DOLL, R, HOWARD, S V, KINLEN, L J and LEWINSON, H C (1977)

A mortality study among workers in an English asbestos factory
Brit. J. industr. Med. 34: 169

PETTY, T L, PIERSON, D J, DICK, N P, HUDSON, L D and WALKER, S H (1976)

Follow-up evaluation of a prevalence study for chronic bronchitis
and chronic airway obstruction
Amer. Rev. Resp. Dis. 114: 881

PIRIE, W R and HAMDAN, M A (1972)

Some revised continuity corrections for discrete distributions
Biometrics 28: 693

POOLEY, F D (1978)

In discussion of Baris et al. (1978)

QAMA (1972)

Geological guide to the asbestos-mining region of south-eastern Quebec

Quebec: QAMA

QAMA (1978a)

Annual production (shipments) 1880-1967. Quebec asbestos shipments, and Canadian shipments, 1968 through 1977. Canadian asbestos shipments, by province, 1977

Mimeographed tables privately circulated

QAMA (1978b)

The production of asbestos in 1977

Bulletin 2: no. 2 (February 1978), p. 7

QUEBEC ASBESTOS MINING ASSOCIATION *see* QAMA

RODRIGUES, M J (1976)

Data processing for the mortality study in the chrysotile asbestos mines and mills of Quebec

M.Sc. dissertation, McGill University

ROGAN, J M (1964)

Medical Service and Medical Research: Annual Report 1963

London: National Coal Board (Medical Service), pp. 39-45

ROSATO, D V (1959)

Asbestos - its industrial applications

New York: Reinhold

ROSSITER, C E (1972a)

Initial repeatability trials of the UICC/Cincinnati classification of the radiographic appearances of pneumoconioses

Brit. J. industr. Med. 29: 407

ROSSITER, C E (1972b)

Relation of lung dust content to radiological changes in
coal workers

Ann. New York Acad. Sci. 200: 465

ROSSITER, C E (1972c)

Evidence of dose-response relation in pneumoconiosis

J. Soc. occup. Med. 22: 83

ROSSITER, C E, BRISTOL, L J, CARTIER, P H, GIBBS, G W, GILSON, J C,
GRAINGER, T R, SIEMIATYCKI, J, SLUIS-CREMER, G K and
McDONALD, J C (1971)

Dust exposure and radiographic appearances in Quebec asbestos
workers. In: *Proceedings of the Sixteenth International Congress
on Occupational Health* Toyoko: Japan Industrial Safety
Association, pp. 205-206

ROSSITER, C E, BRISTOL, L J, CARTIER, P H, GILSON, J C, GRAINGER, T R,
SLUIS-CREMER, G K and McDONALD, J C (1972)

Radiographic changes in chrysotile asbestos mine and mill
workers of Quebec

Arch. environ. Health 24: 388

RUBINO, G F, SCANSETTI, G and PIOLATTO, G (1977)

Asbestos hazards in Italy

Presented at a meeting of the Royal Society of Medicine, London,
28 April 1977

SARACCI, R (1977)

Asbestos and lung cancer: an analysis of the epidemiological
evidence on the asbestos-smoking interaction

Internat. J. Cancer 20: 323

SAUPE, E (1938)

Röntgenatlas der Asbestose der Lunge

Leipzig: G. Thieme

SCHALL, E L (1965)

Present threshold limit value in the USA for asbestos dust:
a critique

Ann. New York Acad. Sci. 132: 316

SCHNEIDERMAN, M A (1974)

Digestive system cancer among persons subjected to occupational
inhalation of asbestos particles: a literature review with
emphasis on dose response

Environ. Health Perspectives 9: 307

SEATON, A (1975)

Asbestosis

In: Morgan and Seaton (1975), p. 124

SELIKOFF, I J, CHURG, J and HAMMOND, E C (1964)

Asbestos exposure and neoplasia

J. Amer. Med. Assoc. 188: 22

SELIKOFF, I J, CHURG, J and HAMMOND, E C (1965)

The occurrence of asbestosis among insulation workers in the
United States

Ann. New York Acad. Sci. 132: 139

SELIKOFF, I J and HAMMOND, E C (1975)

Multiple risk factors in environmental cancer

*In: Proceedings of conference on persons at high risk of cancer:
an approach to cancer etiology and control. 10-12 December, 1964,
Key Biscayne, Florida Published 1975*

SELIKOFF, I J, HAMMOND, E C and SEIDMAN, H (1973)

Cancer risk of insulation workers in the United States

In: Bogovski et al. (1973), pp. 209-216

SELIKOFF, I J, HAMMOND, E C and SEIDMAN, H (1978)

Mortality experience of insulation workers in the United States
and Canada, 1943-1977

Ann. New York Acad. Sci. (in press)

SHETTIGARA, P T and MORGAN, R W (1975)

Asbestos, smoking and laryngeal carcinoma

Arch. environ. Health 30: 517

SLUIS-CREMER, G K and THERON, C P (1965)

A proposed classification of asbestosis

Ann. New York Acad. Sci. 132: 373

STILL, P M and MCGILL, T (1973)

Asbestos and laryngeal carcinoma

Lancet 2: 615

SUTHERLAND, R B (1959)

Respiratory cancer mortality, 1930-57

The International Nickel Company of Canada, Limited, Port Colborne
Refinery. Private report to Department of Health for Ontario,
27 November 1959

TAYLOR, I and KNOWELDEN, J (1957)

Principles of epidemiology, p. 63

London: Churchill

THERIAULT, G P, PETERS, J M and JOHNSON, W M (1974)

Pulmonary function and roentgenographic changes in granite dust
exposure

Arch. environ. Health 28: 23

THOMAS, D C (1977)

Addendum to Liddell, McDonald and Thomas (1977), pp. 483-485

THOMAS, D C (1978)

Matched analysis of case-control studies
Biometrics (in press)

TIMBRELL, V (1973)

Physical factors as etiological mechanisms
In: Bogovski et al. (1973), pp. 295-303

UICC WORKING GROUP ON ASBESTOS AND CANCER (1965a)

Report and recommendations of the Working Group convened under the auspices of the Geographical Pathology Committee of the International Union against Cancer (Union Internationale contre le Cancer, UICC)
Arch. environ. Health 11: 221

UICC WORKING GROUP ON ASBESTOS AND CANCER (1965b)

Recommendations on problems requiring epidemiological study
Brit. J. industr. Med. 22: 165

UNION INTERNATIONALE CONTRE LE CANCER *see* UICC

URY, H K (1975)

Efficiency of case-control studies with multiple controls per case: continuous or dichotomous data
Biometrics 31: 643

Van MECHELEN, V and BELAYEW, - (1948)

The Hasselt classification, *cited by* Van Mechelen and McLaughlin (1962), p. 241

Van MECHELEN, V and McLAUGHLIN, A I G (1962)

The new international classification of radiographs of the pneumoconioses
Ann. occup. Hygiene 4: 237

- Van ORDSTRAND, H S (1977)
Pneumoconioses and their masqueraders
J. occup. Med. 19: 747
- WAGNER, J C, GILSON, J C, BERRY, G and TIMBRELL, V (1971)
Epidemiology of asbestos cancers
Brit. Med. Bull. 27: no. 1, 71
- WAGNER, J C, SLEGGS, C A and MARCHAND, P (1960)
Diffuse pleural mesothelioma and asbestos exposure in the
Northwestern Cape Province
Brit. J. industr. Med. 17: 260
- WARD, E (Ed) (1977)
*Asbestos. IARC Monographs on the Evaluation of the Carcinogenic
Risk of Chemicals to Man, Volume 14*
Lyon: IARC
- WEILL, H and JONES, R (1975)
The chest roentgenogram as an epidemiologic tool
Arch. environ. Health 30: 435
- WEILL, H, ROSSITER, C E, WAGGENSPACK, C, JONES, R N and ZISKIND, M M
(1977)
Differences in lung effects resulting from chrysotile and
crocidolite exposure
In: WALTON, W H (Ed) (1977), Inhaled Particles IV, Pergamon
Press: Oxford and New York, pp. 789-798
- WEILL, H, ZISKIND, M M, WAGGENSPACK, C and ROSSITER, C E (1975)
Lung function consequences of dust exposure in asbestos cement
manufacturing plants
Arch. environ. Health 30: 88
- WEIR, J M and DUNN, J E Jr (1970)
Smoking and mortality: a prospective study
Cancer 25: 105

WEISS, W (1977)

Mortality of a cohort exposed to chrysotile asbestos
J. occup. Med. 19: 737

WHITE, F M, SWIFT, J and BECKLAKE, M R (1974)

Rheumatic complaints and pulmonary response to chrysotile dust
inhalation in the mines and mills of Quebec
Can. Med. Assoc. J. 11: 533

WOOD, W B (1929)

Pulmonary asbestosis - radiographic appearances in Skiagrams
of the chests of workers in asbestos
Tubercle 10: 353

YODEN, W J (1950)

Index for rating diagnostic tests
Cancer 3: 32

YULE, G U (1934)

On some points relating to vital statistics, more especially
statistics of occupational mortality
J. Roy. Statist. Soc. 97: 1

ZENKER, F A (1876)

Diseases of the lungs due to the inhalation of dust
Translated by Micklejohn (1960)

ZUSSMAN, J (1972)

Nature and history (of asbestos)
Review 1972/2 Basle: Ciba-Geigy, pp. 1-8

AppendixI N S T R U C T I O N S F O R U S I N G
U I C C / C I N C I N N A T I C L A S S I F I C A T I O N

The following pages (368 through 374) are reproductions of the earliest known notes on the use of the U/C classification, later published in slightly amended form by Bohlig *et al.* (1970). These instructions bear the "imprint" JCG/MAR, the reference 67/27 and the date 29th December, 1967.

The "Appendix II" referred to at the foot of the first page of the instructions is reproduced here as page 376; a reduced version of the reading sheet of "Appendix I", referred to on the second page of the instructions, is on page 375 of the thesis.

The list of Symbols (see page 374) was not attached to the present copy of the original instructions.

INSTRUCTIONS FOR USING IICC/CINCINNATI CLASSIFICATION

27th December, 1957.

Technique

Inspection for technique:

- if good or acceptable, record "plus" +
- if poor, record "plus/minus" +/-
- if very poor but just readable for some features record +-- and add comments on type of defect
- if unreadable record "minus" -

Only use unreadable if you think the reading is likely to be too doubtful to convey any appreciable information. If unreadable, make a note of why in "comments".

Classification

Look at the film and decide if any of the changes seen in the pleura or the parenchyma are sufficiently characteristic of pneumoconiosis (including that seen in asbestosis) to be recorded in the classification. If it is probable that all the changes seen are the result of some other aetiology do not classify, but record opinion using symbols, e.g., Tb, Np (neoplasm), etc., and by other notes in the "comments" column. If the changes might be due in part to pneumoconiosis record on the classification scheme but make note in "comments" what other aetiology is likely.

Note: there is no provision in this classification for doubtful pneumoconiosis ('?' used in the I.L.O. 1958 classification and the modification of this by the U. S. Public Health Service). The reader is required to make a decision one way or the other, but there is provision within the classification for recording changes which are less than the "first category of "small rounded" and "small irregular opacities".

Small Rounded Opacities

These are classified as on the I.L.O. 1958 scheme as modified by the U. S. Public Health Service (see Appendix II).

INSTRUCTIONS FOR USING UICC/CINCINNATI CLASSIFICATION, 2

Profusion: The profusion is determined using the I.L.O. standard films and the verbal definitions, with the N.C.B. elaboration to give extra information about where the film lies within the I.L.O. categories 0, 1, 2 & 3. The instructions for using the N.C.B. elaboration are: "Record the I.L.O. category into which you would classify the film following the normal convention. If, in the course of that classification, you considered an adjacent category as a serious possibility, record this after the formal category".

The system of coding is shown at the bottom of the reading sheet (Appendix 1) and is a 12-point scale from 0/- to 3/4.

Notes:

- (i) regard the I.L.O. 1958 films as typical (mid-category) films showing 1, 2 and 3.
- (ii) within category 0 record as 0/- those films which are indubitably normal at first glance (barn-door normals)⁴. Those which are normal after a brief inspection are recorded as 0/0. Those in which you seriously considered category 1 before deciding that they were category 0 are recorded as 0/1.
- (iii) although there is no formal category 4, record those films which you regard as being above category 3-standard as 3/4.

Type: On the basis of "averaging" for both lung fields record the predominant type as follows -

- p = pin-head (I.L.O.) small opacities up to 1.5mm.
- q = micronodular (m) (I.L.O.) - opacities with diameters 1.5 to 3mm.
- r = nodular (n) (I.L.O.) - diameters 3 to 10mm.

Notes:

- (i) 'p', 'q', 'r' which should be in small case not capitals, are used in preference to 'P', 'M' and 'N' on the I.L.O. 1958 scheme, because 'm' and 'n' may get confused in writing and in speaking when recording the classification. Also, with 's', 't' and 'u' they form an alphabetic sequence of coding of the type of small opacities.

⁴ (Barn door, "used for a target too large to be missed" Oxford English Dictionary).

INSTRUCTIONS FOR USING WICC/CINCINNATI CLASSIFICATION, 3

Small Irregular Opacities

This group in the classification is used to record those films in which there is a filling of the rib spaces with irregular opacities of various thicknesses, shapes and densities, but which are not clearly rounded. As in the case of the small rounded opacities, the irregular small opacities tend, particularly when present in profusion, to obscure the normal lung architecture. Hence obscuration of the normal lung pattern is a feature of both those films with small rounded and small irregular opacities.

Small irregular opacities may be present alone or with small rounded opacities. Both should be recorded if it is thought both can be convincingly seen on the same film. It may, for example, be possible to see small rounded opacities in the upper zones and small irregular opacities in the lower zones, or vice versa. If only one type of opacity is present, record this and record O/O for the other type.

Profusion: As in the case of rounded small opacities, the profusion of the irregular small opacities is based on an averaging over the whole lung and by comparison with the standard films. However, unlike the small rounded opacities, the profusion of the irregular small opacities is judged purely by reference to the standard films and there is no verbal definition of the extent (number of rib spaces) affected for each category.

Type: The irregular small opacities are divided into three types -

- s = fine, irregular or linear opacities
- t = thick irregular or linear opacities
- u = coarse (blotchy) opacities (not obviously linear)

Notes:

- (i) The type should be decided on the basis of predominant feature of the film taken as a whole. Thus, only one type - 's', 't' or 'u' will be recorded for a film. This is the same convention used for classification of 'p', 'q' or 'r'.
- (ii) On account of the variation in shape and size of the irregular small opacities no dimensions are specified (cf., 'p', 'q', 'r'). Classification of type depends largely on comparison with the standard film. In general, if in doubt record 't'. 's' is used for films in which the pattern is definitely fine and more linear, 'u' for films in which the shadows are 'blotchy' with little evidence of linearity.

6/27

INSTRUCTIONS FOR USING ILO/CINCINNATI CLASSIFICATION, 4

Site of Small "Rounded" or "Irregular" Opacities: in order to provide information about the predominant site (lung zone) in which the small rounded or small irregular opacities are present the reading sheet provides a box with six partitions for recording which zones the opacities are best seen. These boxes should be completed by putting a tick in the appropriate space.

Notes:

- (1) The provision of boxes for recording the zones most affected has been made because, whereas in many types of Pneumoconiosis the upper zones are usually affected first, this is not thought to be so in Asbestosis. The added information about the lung zones most affected may help to separate the changes in the lung appearance associated with different types of dusts.

Large Opacities

In order to cover a wider range of features of large opacities than is described in the I.L.O. 1958 scheme, the large opacities are divided into two types: (i) well-defined, (ii) poorly-defined.

Well-defined: These are the large opacities of the I.L.O. 1958 scheme. Their size is classified according to the largest diameter using the standard films, A, B and C, and the verbal and pictorial definitions in the U. S. Public Health Service extension of the I.L.O. scheme (Appendix II).

Poorly-defined: D, E and F, are used to record large opacities in which the edge of the shadow is markedly ill-defined and yet the appearance is one of a large shadow in the lung parenchyma. The size is recorded using the same definitions as A, B and C opacities.

Notes:

- (1) It is not certain how useful or frequently recorded this type of ill-defined opacity will be. It was introduced to cover the appearances occasionally seen in the asbestos-exposed workers where the large opacities may be much less clearly demarcated from the surrounding lung than in other types of Pneumoconiosis, but the system may be useful to record the ill-defined larger opacities also seen in other types of Pneumoconiosis and which are not well covered by the I.L.O. 1958 scheme.

5/27

INSTRUCTIONS FOR USING WICC/CINCINNATI CLASSIFICATION, 5Pleural Thickening

The type, severity, and site are recorded using standard films, but in order to simplify the classification and improve its specificity certain conventions are used.

Type: Two types are recognized. "Diffuse" and "plaques". When both are present both are recorded (see Appendix I).

A "plaque" is recorded only when an area of pleural thickening has a sharply defined edge and is plate-like but uncalcified. Plaques are usually limited to the wall but if definite should be recorded when present on the diaphragm or elsewhere.

"Diffuse" pleural thickening covers all other types including the narrow linear bands running parallel to the chest wall.

Standard films are provided to demonstrate the appearances and the grading (severity) of pleural thickening.

Site and Severity

Costophrenic angle: Record this as present or absent, right and/or left. A standard lower limit ^{film} is provided. No upper limit film is provided, but the convention is to report "C.P." alone where there is approximately equal length of change along the surface of the diaphragm and up the chest wall. If the thickening extends appreciably further up the chest wall, or along the diaphragm, then the film should be classified as "C.P." and Pleural Thickening (diffuse or plaques) on the wall and diaphragm.

Notes:

- (1) Loafing of the diaphragm should not be recorded as "C.P." even though it leads to the obscuration of the costophrenic angle.

Walls: Pleural thickening on the chest wall is recorded in three grades. Lower limits of these, 1, 2 and 3 are provided in standard films. The grade is averaged for both lung fields together and also for diffuse and/or plaques. The site is recorded as right and/or left.

Diaphragm: Where there is a definite plaque on the diaphragm, this should be recorded as present, right and/or left, and graded as part of a general pleural thickening, affecting the whole film.

INSTRUCTIONS FOR USING WICC/CINCINNATI CLASSIFICATION, 6

Irregularity of Diaphragm and Cardiac Border

There is uncertainty whether the irregularity of the diaphragm and cardiac border which are not uncommon in pneumoconiosis is due to pleural thickening and/or super-imposition of other shadows. The need to record the appearance and severity of change has been provided for as follows:-

Irregular Diaphragm: This is recorded simply as present or absent, right and/or left, using the standard film as lower limit.

Notes:

- (i) The lower limit is intentionally set fairly high as small irregularities of the diaphragm are not thought to be very important epidemiologically.
- (ii) The classification is purely descriptive and therefore, the diaphragm is recorded as irregular whatever the cause, whether this is actual thickening of the pleura, or distortion (if marked), or fuzziness, or if the contour is markedly altered as a result of pleural calcification.
- (iii) Irregularities, considered to be due to leafing, are not recorded.

Irregular Cardiac Border: This is graded using the lower limit standard films 1, 2 and 3 which are based on extent of irregularity rather than degree of fuzziness.

Notes:

- (i) Special attention is given to the left cardiac border.
- (ii) The abnormality recorded is fuzziness of the outline whatever the likely cause (as for irregular diaphragm).
- (iii) Irregularity, thought simply to be due to cardiac fat casting a double shadow along the border is not classified as cardiac irregularity.

Pleural Calcification

This is graded 1, 2 and 3 using the lower limit standard films provided, and recorded right and/or left on the diaphragm and/or the wall. If present in other sites, for example, the mediastinum or the fissure, this is noted in the appropriate column. The grading is averaged over the whole lung -

5/27

INSTRUCTIONS FOR USING ITC/CINCINNATI CLASSIFICATION, 2Pleural Calcification (continued)

Grade 1 : less than 3 square inches (approx. 16 sq.cms.)

Grade 2 : less than 9 square inches (approx. 260 sq.cms.)

Grade 3 : 9 square inches and above (approx. 260 sq.cms.)

Notes:

- (i) Pleural calcification should be assessed, using both the sharpness of definition of the shadow, as well as its density. The comparison of density with neighbouring rib structures may help to decide whether or not it should be graded as a pleural calcification as opposed to a pleural plaque (uncalcified).
- (ii) The total area is estimated by summing the areas as seen on films and allowance is not made for the larger actual area of plaque when it is seen edge on.
- (iii) Calcification thought to be in the wall of the aorta is not recorded.
- (iv) Avoid recording artefacts due to scratches on the screens etc.

Symbols

Certain additional features in the film can be recorded in code, using the list of symbols (see attached list). It is impracticable to record systematically all the symbols, but if a selected few are recorded systematically, this should be noted when reporting results, so that valid comparisons may be made with other surveys.

Symbols of special interest in asbestos workers are likely to include:-

- Np - neoplasm, either bronchial tumour, or mesothelioma.
- Cn - calcification of nodules.
- Co - cardiac abnormality (other than irregularity of cardiac outline reported in the main classification).
- Cp - cor pulmonale.
- Es - eggshell calcification.
- Ho - honeycomb appearance. Note: This is a relatively specific type of appearance which will have already been recorded in the irregular small opacities column under 's', 't' or 'u', but if present to a marked degree may be usefully noted in the symbols.
- Od - other diseases.
- Tb - clinically significant tuberculosis, but excludes primary complex.

U.I.C.C. CINCINNATI CLASSIFICATION OF RADIOGRAPHIC APPEARANCE OF PNEUMOCONIOSES

(1st November 1967)

QUEBEC
ASBESTOS
STUDY

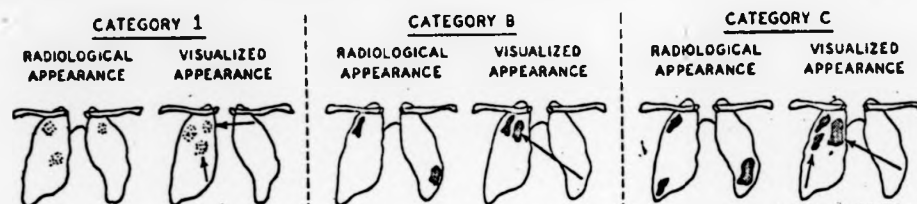
Number	Quality	ROUNDED SMALL OPACITIES			IRREGULAR SMALL OPACITIES			LARGE OPACITIES		PLEURAL THICKENING					IRREGULAR DIAPHRAGM *	IRREGULAR CARDIAC BORDER	PLEURAL CALCIFICATION					Symbols	Comments
		Type	Profusion	Zones R L	Type	Profusion	Zones R L	Well defined	Poorly defined	C.P. angle	Diffuse	Plaques	Grade	None			Diaphragm	Wall	Other	Grade	None		
			/			/																	
			/			/																	
			/			/																	
			/			/																	
			/			/																	

UR	P	0/- 0 0 0 1	Check zones involved	S	0/- 0 0 0 1	Check zones involved	0	0	0		0	0	0	0	0		0	0	0	0	0	0
	A	1/0 1/1 1/2			1/0 1/1 1/2		A	D	R	R	1	R	1	R	1	R	1	R	1	R	1	Cn Co Cp
	E	2/1 2 2 2 3			2/1 2 2 2 3		B	E	L	L	2	L	2	L	2	L	2	L	2	L	2	Es Ho Np
	F	3 2 3 3 3 4			3 2 3 3 3 4		C	F			3		3		3		3		3		3	Od Tb

"Appendix I" to
INSTRUCTIONS FOR USING UICC/CINCINNATI CLASSIFICATION

PNEUMOCONIOSIS		
SMALL OPACITIES	THE CATEGORIZATION DEPENDS ON THE EXTENT AND PROFUSION OF THE OPACITIES:	THESE ARE CLASSIFIED ACCORDING TO THE GREATEST DIAMETER OF THE PREDOMINANT OPACITIES AND DENOTED BY THE FOLLOWING SYMBOLS:
	<ol style="list-style-type: none"> 1. A NUMBER OF OPACITIES IN AN AREA EQUIVALENT TO AT LEAST THE SECOND AND THIRD ANTERIOR RIB SPACES OF EITHER SIDE, AND AT THE MOST, NOT GREATER THAN ONE THIRD OF THE TWO LUNG FIELDS COMBINED. 2. OPACITIES MORE DIFFUSE THAN IN CATEGORY 1 WHICH MAY BE DISTRIBUTED OVER THE WHOLE OR NEARLY THE WHOLE OF THE LUNG FIELDS. 3. VERY NUMEROUS OPACITIES DISTRIBUTED OVER THE WHOLE OR NEARLY THE WHOLE OF THE LUNG FIELDS. 	<p>P - GREATEST DIAMETER UP TO AND INCLUDING 1.5 mm.</p> <p>Q - GREATEST DIAMETER FROM 1.5 mm UP TO AND INCLUDING 3 mm.</p> <p>R - GREATEST DIAMETER FROM 3 mm UP TO AND INCLUDING 5 mm.</p>
LARGE OPACITIES	<p>A - AN OPACITY HAVING A GREATEST DIAMETER EXCEEDING 1 cm. AND UP TO AND INCLUDING 3 cm. OR SEVERAL OPACITIES EACH GREATER THAN 1 cm., THE SUM OF WHOSE GREATEST DIAMETERS DOES NOT EXCEED 3 cm.</p> <p>B - ONE OR MORE OPACITIES LARGER OR MORE NUMEROUS THAN THOSE IN CATEGORY A WHOSE COMBINED AREA DOES NOT EXCEED ONE THIRD OF THE VISIBLE RIGHT LUNG.</p> <p>C - ONE OR MORE OPACITIES WHOSE COMBINED AREA EXCEEDS ONE THIRD OF THE VISIBLE RIGHT LUNG FIELD.</p>	

* THE BACKGROUND OF SMALL OPACITIES SHOULD BE SPECIFIED AS FAR AS POSSIBLE.



361

MORTALITY OF QUEBEC CHRYSOTILE WORKERS
IN RELATION TO
RADIOLOGICAL FINDINGS WHILE STILL EMPLOYED

Francis Douglas Kelly Liddell

Thesis submitted for the degree of
PhD

Volume 2: Annex

*TUC Centenary Institute of Occupational Health
London School of Hygiene and Tropical Medicine*

July 1978



C O N T E N T S O F V O L U M E 2 (A N N E X)

This Annex contains the leading data for all subjects in Cohorts "A" and "B". The contents are as follows:-

COHORT "A"	P a g e
Record lay-out	3
Lay-out of x-ray readings	4
"Normals": Alive	5
"Normals": Dead	47
"Less-than-normals": Alive	51
"Less-than-normals": Dead	135
 COHORT "B"	
Record lay-out	152
Lay-out of x-ray readings	153
Reader 1	154
Reader 2	185
Reader 3	217
Reader 4	249
Reader 5	282
Reader 6	315

RECORD LAY OUT: COHORT "A"

#	Length	Item, including units and "format"
1	6	Identity number
2	4	Height (cm) (F4.1)
3	4	Weight (kg) (F4.1)
4	4	FEV _{1.0} (litres) (F4.2)
5	4	FVC (litres) (F4.2)
6	1	Wheezing
7	1	Number of chest illnesses
8	5	Film reading sequence number
9	1	Status (Alive, Dead or Lost to view)
10	2	Year of death, or loss (blank if alive)
11	3	Cause of death * (blank if alive or lost to view)
12	4	Date of start of first job (year/month)
13	4	Recorded end of last job (year/month = 66/11)
14	2	Net service (years: truncated) (I2)
15	5	Accumulated dust exposure (mpcf.y: truncated) (I5)
16	1	Mining area (Asbestos or Thetford Mines)
17	1	Smoking code (see p. 172)
18	1	"Normal" or "Less-than-normal"
19	6	Date of birth (day/month/year)
20	4	Age at test (years) (F4.2)
21	2	Persistent cough/phlegm (unreliable)
22	1	Breathlessness
23	43	X-ray readings (see next page)

* First character R or S for accidents at asbestos work

LAY-OUT OF X-RAY READINGS: COHORT "A"

Each line (columns 87-129) refers to a specific reader

#	Length	Print cols.	Item
1	1	87	"6"
2	1	88	Film quality (+; +/-; +/--)
3	9	90-92 93-98	Small rounded opacities type; profusion zones (RU; RM; RL; LU; LM; LL)
4	9	100-102 103-108	Small irregular opacities type; profusion zones (RU; RM; RL; LU; LM; LL)
5	2	110-111	Large opacities well defined; poorly defined
6	1	113	Costophrenic angle(s)
7	3	114-116	Pleural thickening diffuse; plaques; grade
8	1	118	Irregular diaphragm
9	1	120	Irregular cardiac border
10	4	122-125	Pleural calcification diaphragm; wall; other; grade
11	1	127	"Additional symbols" (count)
12	1	129	"Comments" (1 = Yes)

COHORT "A"

"Normals": Alive

pp. 6 - 46

0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 214	010051
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 444	012401
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 555	010021
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 666	012101
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	001 777	012745
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 888	012401
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 999	012000

10553 1429	833	454	553	01	14664	A	5635	6611	9	44	1	5
10527 1695	796	300	152	00	11275	A	4733	6611	14	213	1	5
13556 1587	559	355	707	00	15568	A	5404	6611	12	25	1	1
10446 1741	782	408	504	00	42594	A	4707	6611	13	9	1	0
10433 1644	500	307	357	00	14467	A	4601	6611	9	20	1	5
10347 1753	609	410	477	00	1941	A	5606	6611	1	2	1	4
10039 1722	676	363	189	00	12364	A	4107	6611	5	28	1	4

[illegible]

4

10495 1491	494	293	460 00	4600 A	5005 6611 19	1047 1 1
10417 1744	740	411	530 00	12047 A	5005 6611 19	41 1 4
10410 1676	524	275	167 00	1716 A	5005 6611 21	511 1 5
10404 1727	766	467	427 00	4093 A	5005 6611 4	34 1 1
10404 1491	693	262	364 00	4632 A	5005 6611 11	47 1 0
10704 1753	890	321	707 00	11236 A	5105 6611 9	57 1 5
10440 1595	707	252	147 00	10415 A	5005 6611 17	45 1 1

[illegible]

40240 1564	432	256	112 00 1405 A	4201 6611 A	151 1 1
40236 1562	501	266	115 00 1314 A	4205 6611 28	152 1 0
40112 1707	772	347	140 10 11520 A	4203 6611 3	151 5 1
40101 1707	653	276	411 20 2331 A	4204 6611 17	106 1 1
40051 1513	524	274	127 15 4207 A	4305 6611 23	173 1 3
11061 1564	416	316	417 00 7201 A	6100 6611 2	151 3 1
11049 1714	616	461	517 00 4756 A	4201 6611 21	40 1 4

[illegible]

100102 1722	041 314	016 00 12-00 A	0006 6011 2	0 A 4
100097 1664	413 355	016 00 0520 A	0006 6011 10	01 A 10
100075 1676	421 326	002 10 11417 A	0006 6011 2	0 A 5
100076 1901	447 417	567 00 0020 A	0006 6011 2	0 A 5
100015 1676	466 321	006 00 4310 A	0006 6011 12	136 A 8
90256 1613	584 263	017 01 4911 A	0006 6011 21	106 T 1
90244 1903	440 317	024 10 4725 A	0006 6011 1	0 T 1

	0	0	0	000000	000000	17		
	0	0	0	000000	000000	18		
	0	0	0	000000	000000	19		
	0	0	0	000000	000000	20		
	0	0	0	000000	000000	21	000 000	000000
	0	0	0	000000	000000	22		
	0	0	0	000000	000000	23		
	0	0	0	000000	000000	24		
	0	0	0	000000	000000	25		
	0	0	0	000000	000000	26		
	0	0	0	000000	000000	27		
	0	0	0	000000	000000	28		
	0	0	0	000000	000000	29		
	0	0	0	000000	000000	30		
	0	0	0	000000	000000	31	000 000	000000
	0	0	0	000000	000000	32		
	0	0	0	000000	000000	33		
	0	0	0	000000	000000	34		
	0	0	0	000000	000000	35		
	0	0	0	000000	000000	36		
	0	0	0	000000	000000	37		
	0	0	0	000000	000000	38		
	0	0	0	000000	000000	39		
	0	0	0	000000	000000	40		
	0	0	0	000000	000000	41		
	0	0	0	000000	000000	42		
	0	0	0	000000	000000	43		
	0	0	0	000000	000000	44		
	0	0	0	000000	000000	45		
	0	0	0	000000	000000	46		
	0	0	0	000000	000000	47	000 000	000000
	0	0	0	000000	000000	48		
	0	0	0	000000	000000	49		
	0	0	0	000000	000000	50		
	0	0	0	000000	000000	51		
	0	0	0	000000	000000	52		
	0	0	0	000000	000000	53		
	0	0	0	000000	000000	54		
	0	0	0	000000	000000	55		
	0	0	0	000000	000000	56		
	0	0	0	000000	000000	57		
	0	0	0	000000	000000	58		
	0	0	0	000000	000000	59		
	0	0	0	000000	000000	60		
	0	0	0	000000	000000	61	000 000	000000
	0	0	0	000000	000000	62		
	0	0	0	000000	000000	63		
	0	0	0	000000	000000	64		
	0	0	0	000000	000000	65		
	0	0	0	000000	000000	66		
	0	0	0	000000	000000	67		
	0	0	0	000000	000000	68		
	0	0	0	000000	000000	69		
	0	0	0	000000	000000	70		
	0	0	0	000000	000000	71		
	0	0	0	000000	000000	72		
	0	0	0	000000	000000	73		
	0	0	0	000000	000000	74		
	0	0	0	000000	000000	75		
	0	0	0	000000	000000	76		
	0	0	0	000000	000000	77		
	0	0	0	000000	000000	78		
	0	0	0	000000	000000	79		
	0	0	0	000000	000000	80		
	0	0	0	000000	000000	81		
	0	0	0	000000	000000	82		
	0	0	0	000000	000000	83		
	0	0	0	000000	000000	84		
	0	0	0	000000	000000	85		
	0	0	0	000000	000000	86		
	0	0	0	000000	000000	87		
	0	0	0	000000	000000	88		
	0	0	0	000000	000000	89		
	0	0	0	000000	000000	90		
	0	0	0	000000	000000	91		
	0	0	0	000000	000000	92		
	0	0	0	000000	000000	93		
	0	0	0	000000	000000	94		
	0	0	0	000000	000000	95		
	0	0	0	000000	000000	96		
	0	0	0	000000	000000	97		
	0	0	0	000000	000000	98		
	0	0	0	000000	000000	99		
	0	0	0	000000	000000	100		

100193 1611 562 212 125 00 1144 A	5	503 11 22 12 5 A 5
100179 1707 661 456 325 00 2325 A	9	5603 6611 5 9 A 4
100164 1607 937 357 111 10 8650 A	1	7007 6611 25 1 56 A 1
100161 1671 535 366 517 00 11106 A	4	4311 6611 16 43 A 4
100141 1466 767 147 465 00 16645 A	1	7007 6611 14 19 A 4
100139 1451 703 141 190 00 14905 A	1	7007 6611 16 41 A 0
100135 1697 792 406 495 00 10746 A	1	6505 6611 1 3 A 1

[illegible]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	1																																																																																								

1005M0 1626	451	101	795 00	7105 A	4493 6611 31	131 A 4
100549 1714	410	337	457 12	4580 A	4501 6611 31	45 A 1
100534 1668	745	244	728 00	5216 A	2710 6611 16	1055 A 1
100523 1749	650	471	524 10	15073 A	6507 6611 1	2 A 4
100520 1714	472	224	314 20	14240 A	4119 6611 23	291 A 5
100497 1749	475	307	360 00	13191 A	2707 6611 34	67 A 1
100447 1671	734	274	332 10	1169 A	2611 6611 43	136 A 4

[illegible]

100670 1595	777	776	327 10	7100 A	1704 6611 17	171 A 5 1
100672 1727	106	307	362 29	2050 A	1400 6611 20	140 A 4 1
100657 1707	542	792	165 00	1420 A	4207 6611 24	50 A 4 1
100453 1722	720	304	407 03	2752 A	4103 6611 17	136 A 5 1
100630 1646 1704	243	347 00	17346 A	4506 6611 21	50 A 4 1	50 A 4 1
100624 1703	776	111	444 00	1474 A	1705 6611 21	45 A 1 1
100631 1727	674	416	624 10	7200 A	5405 6611 2	5 A 5 1

[illegible]

100769 1526	479 438	335 11 12276 A	1334 6611 21	92 A 1
100764 1753	777 361	405 00 12284 A	4212 6611 23	242 A 5
100743 1727	640 307	150 00 14214 A	5603 6611 A	R A 4
100711 1707	797 367	464 00 12305 A	4712 6611 14	130 A 4
100704 1631	563 254	367 00 7044 A	1402 6611 42	206 A 4
100687 1707	678 403	547 10 230 A	4505 6611 1	3 A 4
100679 1710	639 407	477 00 13614 A	5603 6611 19	56 A 4

[illegible]

101115 1581	105	240	201	02	2644	A	1705 6611 22	644	A	6
101334 1581	679	902	392	10	2924	A	1705 6611 11	71	A	2
101331 1714	264	440	506	00	9114	A	1707 6611 02	61	A	1
100444 1714	471	124	125	00	13423	A	1400 6611 32	331	A	5
100976 1774	727	171	523	10	15659	A	1724 6611 17	170	A	4
100262 1446	684	337	385	00	8714	A	5605 6611 1	7	A	1
100999 1540	549	212	274	20	6178	A	1004 6611 17	94	A	1

[illegible]

101431 1431	477	371	137	00	17000	A	4611 6611 19	73 A 0 1
101384 1722	1033	140	459	00	14440	A	4505 6611 1	2 A 0 1
101336 1702	742	135	424	10	3161	A	4501 6611 20	140 A 1 1
101304 1740	903	442	472	00	3072	A	4708 6611 19	92 A 4 1
101205 1714	403	343	480	00	2647	A	2905 6611 37	115 A 4 1
101194 1727	366	412	544	00	6066	A	4407 6611 2	5 A 5 1
101167 1707	930	351	481	22	1349	A	4709 6611 14	104 A 4 1

[illegible]

[illegible]

101621 1646 658 295 369 03 10238 A	1311 6-11 33	27 A 1
101642 1697 714 376 469 09 1131 A	7303 6-11 3	7 A 1
101656 1727 743 769 452 03 4166 A	5538 6-11 2	5 A 0 1
101673 1748 776 364 413 03 4206 A	4732 6-11 19	74 A 0 1
101686 1727 744 478 572 03 15190 A	4504 6-11 1	3 A 4 1
101588 1646 645 236 111 23 4331 A	2104 6-11 43	683 A 4 1
220133 1676 725 413 442 03 1620 A	1724 6-11 5	11 A 0 1

[illegible]

200107 1707	729	327	74~ 10	777- A	4313 6411 35	114 A 8
200074 1778	763	435	519 00	1593 A	4607 6611 12	66 A 1
200087 1707	604	244	367 00	15265 A	4107 6611 35	160 A 4
200074 1575	694	157	274 20	6544 A	4508 6611 21	36 A 4
200052 1432	484	310	344 00	11937 A	4304 6611 34	206 A 4
200035 1613	725	325	304 12	15127 A	4609 6611 20	44 A 4
200374 1714	653	403	373 20	6449 A	4704 6611 14	52 A 4

[illegible]

220109 1513 705 303 700 10 12891 A	9504 6611 11 103 A 4 1
220109 1589 610 287 402 10 14301 A	9504 6611 11 103 A 4 1
220145 1707 723 424 522 00 12037 A	9504 6611 11 103 A 4 1
220141 1702 767 360 432 00 7464 A	9504 6611 11 103 A 4 1
220127 1689 695 104 205 20 6404 A	9504 6611 11 103 A 4 1
220119 1704 813 357 407 00 1095 A	9504 6611 11 103 A 4 1
220105 1707 897 144 423 03 11351 A	9504 6611 11 103 A 4 1

0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	100	549	000521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	100	110	549521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	100	542	549521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	100	542	549521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	000	120	122021
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	000	100	000521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	200	522	000521
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19			
0	0	0	0	000000	000000	19	100	542	202211

200244 1 554	545	735	504 10 1717 A	400 6611 17	400 A 0
200243 1722	545	734	172 00 2100 A	400 6611 21	100 A 0
200242 1547	505	707	152 10 1554-1 A	6211 6611 A	0 A 0
200242 1556	704	704	417 20 4410 A	400 6611 20	40 A 0
200228 1748	770	401	454 00 3002 A	5505 6611 0	10 A 0
200219 1747	654	724	442 20 4410 A	6604 6611	0 A 0
200206 1671	604	435	450 00 4474 A	400 6611 14	43 A 0

[illegible]

200250	1697	794	263	312	00	5344	A	4103	6611	21	52	A	1	1
200330	1722	748	430	492	10	10202	A	6506	6611	1	2	A	3	1
200363	1664	708	380	456	10	11360	A	9105	6611	15	33	A	4	1
200379	1676	788	297	372	00	3973	A	3007	6611	36	165	A	3	1
200393	1829	891	377	480	10	14905	A	4604	6611	20	32	A	5	1
200395	1765	761	273	403	10	11918	A	5805	6611	2	5	A	4	1
300019	1714	753	335	432	20	1059	A	4105	6611	16	112	T	5	1

[illegible]

[illegible]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13</																																																																																							

300632	1682	572	340	436 00	4491 A	5207 6611 14	28 1 0
300642	1626	572	322	394 13	10571 A	5636 6611 3	13 1 4
300665	1708	435	430	521 00	10936 A	1907 6611 11	69 1 4
300711	1621	565	252	102 00	11174 A	2405 6611 37	0446 1 5
30082	1754	358	418	500 00	1666 A	6207 6611 2	9 1 0
300843	1661	754	342	435 00	12023 A	6032 6611 5	10 1 3
300836	1758	714	370	504 00	1244 A	4103 6611 23	211 1 4

[illegible]

300273 1611 522 948 448 00 555 A	300273 1611 522 948 448 00 555 A
300242 1664 618 268 106 00 4832 A	300242 1664 618 268 106 00 4832 A
300241 1692 364 172 412 00 6989 A	300241 1692 364 172 412 00 6989 A
300230 1712 762 348 348 00 12521 A	300230 1712 762 348 348 00 12521 A
300208 1708 915 471 582 10 11519 A	300208 1708 915 471 582 10 11519 A
300199 1707 638 401 433 10 11545 A	300199 1707 638 401 433 10 11545 A
300176 1740 745 182 425 00 2490 A	300176 1740 745 182 425 00 2490 A

[illegible]

301415 1765	446	311	424 10	506 A	3604 6611 28	285 1 4 1
301313 1980	731	421	441 10	1965 A	4006 6611 2	15 1 4 1
301274 1520	309	171	254 10	4969 A	2501 6611 41	436 1 4 1
301273 1651	649	267	131 10	14924 A	4107 6611 25	259 1 4 1
301217 1714	461	444	450 00	5720 A	1606 6611 10	127 1 0 1
301166 1689	621	347	445 20	14121 A	5006 6611 11	76 1 4 1
300984 1714	663	425	440 10	2263 A	6306 6611	1 1 4 1

0	0	0	0	000000	000000	79
0	0	0	0	000000	000000	80
0	0	0	0	000000	000000	81
0	0	0	0	000000	000000	82
0	0	0	0	000000	000000	83
0	0	0	0	000000	000000	84
0	0	0	0	000000	000000	85
0	0	0	0	000000	000000	86
0	0	0	0	000000	000000	87
0	0	0	0	000000	000000	88
0	0	0	0	000000	000000	89
0	0	0	0	000000	000000	90
0	0	0	0	000000	000000	91
0	0	0	0	000000	000000	92
0	0	0	0	000000	000000	93
0	0	0	0	000000	000000	94
0	0	0	0	000000	000000	95
0	0	0	0	000000	000000	96
0	0	0	0	000000	000000	97
0	0	0	0	000000	000000	98
0	0	0	0	000000	000000	99
0	0	0	0	000000	000000	00
0	0	0	0	000000	000000	01
0	0	0	0	000000	000000	02
0	0	0	0	000000	000000	03
0	0	0	0	000000	000000	04
0	0	0	0	000000	000000	05
0	0	0	0	000000	000000	06
0	0	0	0	000000	000000	07
0	0	0	0	000000	000000	08
0	0	0	0	000000	000000	09
0	0	0	0	000000	000000	0A
0	0	0	0	000000	000000	0B
0	0	0	0	000000	000000	0C
0	0	0	0	000000	000000	0D
0	0	0	0	000000	000000	0E
0	0	0	0	000000	000000	0F
0	0	0	0	000000	000000	10
0	0	0	0	000000	000000	11
0	0	0	0	000000	000000	12
0	0	0	0	000000	000000	13
0	0	0	0	000000	000000	14
0	0	0	0	000000	000000	15
0	0	0	0	000000	000000	16
0	0	0	0	000000	000000	17
0	0	0	0	000000	000000	18
0	0	0	0	000000	000000	19
0	0	0	0	000000	000000	1A
0	0	0	0	000000	000000	1B
0	0	0	0	000000	000000	1C
0	0	0	0	000000	000000	1D
0	0	0	0	000000	000000	1E
0	0	0	0	000000	000000	1F
0	0	0	0	000000	000000	20
0	0	0	0	000000	000000	21
0	0	0	0	000000	000000	22
0	0	0	0	000000	000000	23
0	0	0	0	000000	000000	24
0	0	0	0	000000	000000	25
0	0	0	0	000000	000000	26
0	0	0	0	000000	000000	27
0	0	0	0	000000	000000	28
0	0	0	0	000000	000000	29
0	0	0	0	000000	000000	2A
0	0	0	0	000000	000000	2B
0	0	0	0	000000	000000	2C
0	0	0	0	000000	000000	2D
0	0	0	0	000000	000000	2E
0	0	0	0	000000	000000	2F
0	0	0	0	000000	000000	30
0	0	0	0			

301724	1676	737	107	200	10	12642	A	2702	6611	76	323	1	4	1
301662	1676	916	467	540	00	0171	A	6205	6611	7	19	1	5	1
301639	1773	701	407	571	00	9550	A	6305	6611	1				1
301625	1707	953	261	350	00	0038	A	4207	6611	24	578	1	3	1
301565	1765	755	424	555	10	1441	A	4705	6611	19	39	1	5	1
301526	1758	904	443	523	00	1174	A	5606	6611	10	7	1	0	1
301459	1613	519	215	304	10	11472	A	3902	6611	29	2622	1	4	1

[illegible]

302053 1682	783	321	470 00	2700 A	4536 6611 20	69 1 5 1
302051 1671	699	324	427 00	0050 A	4437 6611 22	46 1 5 1
302046 1702	693	292	152 10	0850 A	1501 6611 49	57 1 0 1
302009 1664	671	373	431 10	1700 A	4107 6611 17	42 1 5 1
301996 1778	850	128	516 20	2580 A	6001 6611 6	40 1 5 1
301990 1740	912	298	374 00	1165 A	3506 6611 20	416 1 1 1
301806 1590	504	131	173 10	11657 A	1405 6611 24	076 1 0 1

[illegible]

302102 1774	955	329	447	10	9504	A	5037	6611	7	14	T	5
302115 1714	602	314	511	11	4107	A	7405	6611	10	233	T	4
302174 1740	694	403	475	00	4107	A	5106	6611	15	32	T	4
302196 1773	740	131	404	10	5476	A	4405	6611	21	324	T	3
302199 1727	694	426	471	00	9456	A	4037	6611	3	5	T	4
302304 1695	691	362	445	00	2904	A	4304	6611	2	4	T	4
400003 1745	746	134	421	10	14031	A	4013	6611	17	59	T	5

[illegible]

400265	1505	548	204	170 00	1747 A	4004 6411 14	46
400225	1481	553	417	427 00	703 A	4110 6411 5	32
400199	1702	935	415	527 00	1407 A	4107 6411 1	28
400185	1626	543	436	444 00	4268 A	5104 6411 15	37
400161	1727	694	451	531 00	865 A	6001 6411 4	3
400156	1702	544	205	175 00	5016 A	4710 6411 23	140
400085	1702	621	164	402 00	11166 A	5004 6411 16	88

400365 1539	501 245 208 03 9105 A	5132 6611 15	40 T A
400345 1691	988 274 124 00 5716 A	5013 6611 16	104 T 1
400335 1740	712 143 467 12 4020 A	4512 6611 19	219 T A
400316 1712	695 491 549 00 5566 A	4307 6611 1	12 T A
400289 1793	522 495 533 10 9082 A	4308 6611 19	46 T A
400294 1701	744 341 528 00 9544 A	5707 6611 3	4 T A
400274 1732	442 303 420 10 3707 A	5008 6611 7	20 T 5

[illegible]

4003000	1707	600	171	469	02	5693	A	6707	6611	1
4003000	1740	404	204	147	00	6792	A	6705	6611	41
4003000	1903	919	314	340	01	2517	A	1005	6611	23
4003000	1714	751	374	464	10	12365	A	6710	6611	4
4003000	1707	744	351	464	12	5440	A	4011	6611	17
4004000	1740	661	404	430	00	16080	A	6707	6611	4
5000002	1956	630	243	422	10	7702	A	6711	6611	1

[illegible]

5

500074 1714	506	809	418 17	427 A	6511 6511	1
500067 1564	324	329	419 00	2424 A	6511 6511	1
500054 1676	456	473	442 00	1764 A	6511 6511	1
500056 1727	467	374	493 10	10378 A	6511 6511	1
500055 1753	304	440	547 00	15457 A	6511 6511	1
500023 1651	495	175	307 10	445 A	6511 6511	1
500019 1540	419	427	495 00	4957 A	6511 6511	1

[illegible]

5

500194	1722	716	410	127	00	2109	A	6511	6611	1	2	1	5
500176	1600	752	254	132	00	5276	A	6511	6611	1	4	1	4
500146	1651	899	241	335	00	15100	A	6511	6611	1	2	1	1
500123	1631	622	127	367	20	12520	A	6511	6611	1	2	1	5
500105	1745	640	109	544	00	14280	A	6511	6611	1	4	1	4
500095	1651	536	293	479	00	15557	A	6511	6611	1	2	1	0
500091	1702	690	149	437	00	7722	A	6511	6611	1	2	1	1

[illegible]

500194 1575	551	264	755 10	4232 A	4511 6611	1	2 1 5 1
500221 1712	435	374	469 00	1631 A	4403 6611	14	9 1 5 1
500254 1664	736	379	443 00	11451 A	6511 6611	1	2 1 0 1
500264 1778	494	369	432 00	13454 A	4511 6611	1	6 1 4 1
500327 1722	451	460	521 00	10296 A	6511 6611	1	2 1 3 1
500334 1702	689	314	199 00	650 A	6511 6611	1	2 1 4
500344 1526	585	322	300 00	761 A	6511 6611	1	6 1 5

[illegible]

500000 1765	619	435	562	00	2360	A	5511 6611 11	07	1
500015 1765	826	424	478	10	9629	A	5511 6611 11	08	1
500011 1727	692	372	416	00	2224	A	5511 6611 11	09	1
500347 1740	774	292	352	00	14124	A	5511 6611 11	2	1
500346 1753	500	114	347	10	7293	A	5511 6611 11	2	1
500342 1564	707	116	430	10	6239	A	5511 6611 11	6	1
500341 1714	551	349	414	10	15637	A	5511 6611 11	2	1

[illegible]

600142	1714	574	422	473	03	11721	A	5506	6611	11	45	1	3
600100	1595	625	292	261	13	7418	A	4534	6511	23	362	1	2
600096	1727	726	276	765	13	11010	A	4636	6611	23	597	1	1
600094	1676	649	144	426	03	13682	A	5501	6611	11	47	1	3
600066	1597	615	314	410	09	783	A	5135	6611	15	31	1	4
600061	1651	671	261	734	03	1399	A	4411	6611	14	242	1	5
600054	1732	593	262	404	20	6025	A	4713	6611	14	412	1	4

[illegible]

[illegible]

700157 1727 673 454 530 03 8420 A	5435 6611 17	10 1 1
700159 1643 470 206 516 03 4027 A	5437 6611 6	14 1 5
700274 1538 728 193 344 03 1465 A	5417 6611 7	19 1 4
700214 1600 638 316 387 10 12035 A	5434 6611 9	50 1 4
700137 1758 571 442 573 13 8765 A	5410 6611 9	46 1 4
700070 1656 545 435 511 03 2559 A	6411 6611 2	1 1 4 1
700079 1732 746 478 525 02 459 A	5435 6611 9	23 1 1 1

0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	200 000	151511
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 000	207811
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 255	205111
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	100 014	225021
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 000	009611
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	000 000	201511
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19		
0	0	0	0	000000	000000	19	514 010	200021

700471 1714	565	152	391 03 11424 A	5934 6611	4	17 1 5
700444 1693	742	345	452 00 15047 A	6411 6611	2	4 1 5
700410 1403	416	345	402 00 4512 A	5905 6611	9	17 1 3
700390 1654	627	234	292 10 3337 A	5704 6611	2	54 1 0
700372 1791	796	361	470 02 956 A	5405 6611	12	25 1 5
700363 1707	730	415	362 00 5748 A	6011 6611	5	17 1 0
700359 1651	502	414	392 00 14391 A	5911 6611	13	20 1 4

[illegible]

1194161 1 5/15/97 03 010 228 204 2221 519002

11.9 100 6.29 100 50.5 14.6 21.4 6.21 60.600

01 11-0 5000 0 20001 00 000 001 204 0001 00000

[illegible]

01 1129 1685 4 0034 00 724 143 804 4641 01004

1109 1135 8 21-001 12 2000 12 8-01 22-0000

J. Neurosci., 1997, 17(10):3681-3692

REPRODUCED
FROM
BEST AVAILABLE
COPY

[illegible]

[illegible]

[illegible]

1	0	0	0	000000	000000	20	
0	0	0	0	000000	000000	19	
0	0	0	0	000000	000000	18	
0	0	0	0	000000	000000	27	
0	0	0	0	000000	000000	26	
0	0	0	0	000000	000000	25	
0	0	0	0	000000	000000	24	112277 345 002
0	0	0	0	000000	000000	14	
0	0	0	0	000000	000000	13	
0	0	0	0	000000	000000	12	
0	0	0	0	000000	000000	11	
0	0	0	0	000000	000000	10	
0	0	0	0	000000	000000	09	
0	0	0	0	000000	000000	08	
0	0	0	0	000000	000000	07	
0	0	0	0	000000	000000	06	
0	0	0	0	000000	000000	05	
0	0	0	0	000000	000000	04	121247 440 002
0	0	0	0	000000	000000	03	
0	0	0	0	000000	000000	02	
0	0	0	0	000000	000000	01	
0	0	0	0	000000	000000	00	200 205 109001
0	0	0	0	000000	000000	19	
0	0	0	0	000000	000000	18	
0	0	0	0	000000	000000	17	
0	0	0	0	000000	000000	16	
0	0	0	0	000000	000000	15	
0	0	0	0	000000	000000	14	200 205 109001
0	0	0	0	000000	000000	13	
0	0	0	0	000000	000000	12	
0	0	0	0	000000	000000	11	
0	0	0	0	000000	000000	10	
0	0	0	0	000000	000000	09	
0	0	0	0	000000	000000	08	
0	0	0	0	000000	000000	07	
0	0	0	0	000000	000000	06	
0	0	0	0	000000	000000	05	
0	0	0	0	000000	000000	04	201 202 101101
0	0	0	0	000000	000000	03	
0	0	0	0	000000	000000	02	
0	0	0	0	000000	000000	01	
0	0	0	0	000000	000000	00	120500 344 101
0	0	0	0	000000	000000	19	
0	0	0	0	000000	000000	18	
0	0	0	0	000000	000000	17	
0	0	0	0	000000	000000	16	
0	0	0	0	000000	000000	15	
0	0	0	0	000000	000000	14	101 101 000
0	0	0	0	000000	000000	13	
0	0	0	0	000000	000000	12	
0	0	0	0	000000	000000	11	
0	0	0	0	000000	000000	10	
0	0	0	0	000000	000000	09	
0	0	0	0	000000	000000	08	
0	0	0	0	000000	000000	07	
0	0	0	0</				

900339 1702	457	297	407	12	3440 A	6005 6411 24	154 T A
900325 1401	714	501	521	00	13327 A	6006 6411 3	26 T A
900311 1400	747	304	400	10	5439 A	6007 6411 24	12 T A
900303 1405	355	215	304	20	14477 A	6008 6411 26	2407 T A
900171 1751	319	405	490	10	1466 A	6010 6411 5	15 T A
900147 1753	667	395	472	14	4000 A	6003 6411 6	13 T A
900126 1408	435	393	444	10	6006 A	6005 6411 5	31 T A

[illegible]

900122 1676	904 137 415 02 15067 A	8604 6611 20	211 1 8
900110 1691	926 292 101 12 11608 A	8604 6611 20	65 1 5
900175 1699	720 255 300 20 13352 A	1004 6611 27	2136 1 1
900068 1737	906 706 276 10 11808 A	9005 6611 26	61 1 5
900054 1651	716 359 422 00 3067 A	4706 6611 19	65 1 0
900042 1690	964 477 572 00 15640 A	0504 6611 1	1 0
900041 1753	948 336 440 11 161 A	4507 6611 21	592 1 5

COHORT "A"

"Normals": Dead

pp. 48 - 50

[illegible]

10823 1664	723	330	394 02	7948 0	73 157	4309	6611	12	69	T	0	1
900004 1613	639	242	355 12	14979 0	72 161	4901	6611	19	124	T	4	1
80425 1702	971	315	390 10	11198 0	75 162	4302	6611	43	430	A	4	1
200042 1707	757	362	464 00	15655 0	75 162	5207	6611	14	27	A	4	1
200380 1727	826	301	411 00	2405 0	70 162	3502	6611	31	102	A	4	1
300146 1649	963	364	429 10	6491 0	73 162	4709	6611	19	54	T	4	1
400029 1829	946	368	445 23	2537 0	73 162	4709	6611	19	368	T	4	1

[illegible]

90120 1671	390	304	297 00 13114 0 72 428 1407 6611 20	11 55 1 5
10412 1707	426	207	284 10 17619 0 71 420 3701 6611 22	214 1 5
301741 1916	957	115	264 21 2144 0 74 321 3406 6611 26	205 1 5
300724 1618	631	259	326 20 15522 0 74 207 1710 6611 27	160 1 5
100415 1732	720	432	404 00 13474 0 74 307 4608 6611 20	153 4 3
101214 1748	950	348	404 03 4698 0 70 120 4707 6611 19	39 4 4
702307 1600	640	221	299 10 1440 0 72 177 3701 6611 20	397 1 5

[illegible]

302155 1731 747 412 502 00 1048 0 73 444 430 6611 2
 600046 1743 903 329 447 00 11312 0 74 420 5708 6611 1
 300305 1651 753 274 365 00 11019 0 64 420 3603 6611 2
 200461 1613 662 254 320 20 5732 0 74 420 2403 6611 4
 101016 1702 219 371 444 00 12042 0 74 420 4304 6611 22
 90254 1727 610 262 378 00 8159 0 74 420 3702 6611 1
 30213 1489 611 240 343 00 4561 0 71 420 4306 6611 22

COHORT "A"

"Less-than-normals": Alive

pp. 52 - 134

[illegible]

[illegible]

10185 1587	987	176	257	00	14450	A	2501 6611	14	758	1	2
10206 1626	659	322	378	10	13893	A	5010 6611	9	10	1	4
10207 1576	946	310	369	00	2670	A	4510 6611	13	209	1	3
10291 1585	702	233	359	10	7604	A	2006 6611	37	480	1	5
10299 1753	940	249	342	00	2219	A	2306 6611	33	333	1	3
10111 1664	735	340	406	00	2917	A	4207 6611	22	94	1	3
10141 1765	690	293	379	00	12129	A	4213 6611	23	289	1	3

0 0	0	0	000000	000000	19	
0 0	0 7	0	000000	000000	19	
1 0	0	0	100100011	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	000 205

0 0	0	0	001001101	00000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	110111011	000000	19	
0 0	0	0	010111011	00000000	19	
1 0	0	0	000000	000000	19	
0 0	0	0	110110215	000000	19	110 205

0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	100110101	000000	19	
1 0	0	0	100100101	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	100 154

0 0	0	0	000000	000000	19	
0 0	0	0	000000	100100101	19	
0 0	0	0	000000	100100101	19	
0 0	0	0	000000	000000	19	
0 0	0	0	100100101	000000	19	
0 0	0	0	110110011	100110101	19	003 025

0 0	0	1	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	110110101	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	1	000000	000000	19	000 954

0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	110111101	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	000 125

0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	
0 0	0	0	000000	000000	19	000 024

10485 1273 751 147 444 20 12284 A	4201 6611 14	130 T 5 2 11200
10463 1451 825 289 194 00 12097 A	4537 6611 20	158 T 2 2 132760
10457 1454 1068 407 444 10 7157 A	4439 6611 19	56 T 5 2 122105
10424 1791 841 217 125 22 1685 A	4109 6611 14	131 T 4 2 115664
10509 1740 823 353 405 20 14422 A	3409 6611 11	120 T 5 2 124075
10463 1924 403 241 125 00 17482 A	4536 6611 21	27 T 2 2 110174
10421 1707 600 403 544 00 11690 A	4711 6611 13	12 T 4 2 124432

[illegible]

55

10918 1681 321 234 241 02 333 A	2613 6611 11
13800 1671 598 430 527 00 266 A	5906 6611 11
13775 1676 312 232 295 12 256 A	4513 6611 13
10762 1676 948 212 253 00 12178 A	4706 6611 9
13723 1664 642 245 312 00 4545 A	4509 6611 20
10713 1656 665 162 305 20 13912 A	4502 6611 19
10697 1702 721 373 451 00 1176 A	4624 6611 13

[illegible]

10005 1619	604	240	124 00	5396 A	1410 6611 20	165 T
10001 1727	925	210	755 10	7595 A	1204 6611 14	162 T
10991 1707	719	297	191 00	4240 A	1703 6611 21	900 T
10853 1722	789	349	452 00	13923 A	5102 6611 15	45 T
10882 1714	402	262	353 22	13577 A	1307 6611 29	1455 T
10881 1691	708	266	319 20	14846 A	4401 6611 22	210 T
10828 1451	707	141	424 10	11580 A	1110 6611 21	552 T

[illegible]

LS

11034 1791	374	176	450 00 15604 A	5402 6611 7
11070 1626	758	323	398 00 13405 A	5107 6611 6
11029 1403	490	103	132 00 5386 A	4009 6611 26
11013 1697	698	126	423 00 12047 A	4407 6611 21
11014 1681	744	156	379 00 10421 A	5536 6611 9
11010 1748	709	395	455 02 15052 A	6203 6611 4
11009 1675	713	267	341 00 4303 A	5004 6611 13

[illegible]

80021 1691 763 261 325 20 1557 A	3704 6611 29	361 T
80024 1707 667 214 291 00 6903 A	2709 6611 19	225 T
80032 1702 751 309 189 10 8247 A	1911 6611 31	2390 T
80044 1702 873 256 135 00 8181 A	2604 6611 32	2004 T
80069 1634 653 193 125 10 9970 A	2704 6611 27	2024 T
80073 1727 689 202 440 00 1474 A	3701 6611 13	124 T
80077 1570 519 236 296 10 11361 A	2102 6611 43	111

0	0	0	1	1	00000	00000
0	0	1	0	1	100100	00000
0	0	0	0	1	00000	00000
1	0	0	0	1	00000	00000
1	0	1	0	1	00000	00000

[illegible]

1	0	0	0	000000	000000
1	0	0	0	000000	000000
1	0	0	0	100110011	000000
1	0	0	0	000000	000000
1	0	0	0	100100104	000000
1	0	0	0	100100011	000000

C	O	C	G	6C00C	00000
C	O	C	G	00000	00000
I	O	C		110111121	00000
C	C	C	L	100100101	00000
C	C	C	C	00000	00000
C	O	O	O	110110101	00000

[illegible]

0	0	0	0	000000	000000
0	0	0	0	000000	000000
0	0	0	0	100100101	000000
0	0	0	0	000000	000000
0	0	0	0	000000	000000
0	0	0	0	000000	000000

0	0	0	000000	000000
0	0	0	000000	000000
0	0	0	100100101	000000
0	0	0	000000	000000
0	0	0	000000	000000
0	0	0	000000	000000

[illegible]

40194 1431 694 337 749 00 4541 A	4701 6411 14
40179 1744 402 124 443 00 12440 A	4701 6411 14
40173 1441 454 131 250 13 9980 A	4610 6411 34
40166 1624 790 173 251 00 10042 A	2404 6411 14
40145 1444 774 245 313 13 9293 A	4510 6411 13
40128 1451 746 177 249 12 3330 A	2410 6411 35
40114 1531 443 227 292 13 4424 A	3404 6411 18

[illegible]

Year	Month	Day	Time	Location	Event	Remarks
1967	10	10	10:00	101	101	101
1967	10	11	10:00	101	101	101
1967	10	12	10:00	101	101	101
1967	10	13	10:00	101	101	101
1967	10	14	10:00	101	101	101
1967	10	15	10:00	101	101	101
1967	10	16	10:00	101	101	101
1967	10	17	10:00	101	101	101
1967	10	18	10:00	101	101	101
1967	10	19	10:00	101	101	101
1967	10	20	10:00	101	101	101
1967	10	21	10:00	101	101	101
1967	10	22	10:00	101	101	101
1967	10	23	10:00	101	101	101
1967	10	24	10:00	101	101	101
1967	10	25	10:00	101	101	101
1967	10	26	10:00	101	101	101
1967	10	27	10:00	101	101	101
1967	10	28	10:00	101	101	101
1967	10	29	10:00	101	101	101
1967	10	30	10:00	101	101	101
1967	10	31	10:00	101	101	101

90213 15P0 574 216 204 10 1311 A	1704 6611 14	214 1 3 2 110473
9023M 1740 492 310 404 10 1477 A	1705 6611 1	5 1 5 2 111073
90230 1544 671 227 272 02 11346 A	4104 6611 1	4 1 4 2 102765
90245 1651 536 140 256 60 2050 A	2910 6611 1	A 1 4 2 100394
90353 1597 513 104 420 00 3010 A	0933 6611 3	40 1 2 2 103391
90259 1651 679 250 103 00 14605 A	1430 6611 11	104 1 4 2 105017
90397 1607 401 126 434 20 15653 A	2904 6611 20	204 A 5 2 104714

[illegible]

100000 1424 414 404 478 01 4691 A	4005 6611 17
100029 1271 746 245 354 11 10534 A	5131 6611 15
100010 1403 709 342 454 10 3447 A	7501 6611 31
80525 1613 646 210 254 10 12649 A	1411 6611 43
80524 1575 721 314 353 00 8177 A	1601 6611 13
80408 1690 644 243 240 00 4740 A	2710 6611 31
80325 1446 532 146 253 10 15663 A	7010 6611 22

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	5
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	---

100181 1639	601 396	450 00	4134 A	5504 6611 11
100176 1631	735 205	277 00	1090 A	2505 6611 10
100149 1727	692 262	171 00	4372 A	1613 6611 04
100128 1702	795 260	127 10	11965 A	2709 6611 15
100127 1697	736 301	366 10	12666 A	4410 6611 21
100076 1595	704 140	216 00	11313 A	1934 6611 12
100041 1579	762 210	294 13	762 A	1433 6611 12

7	146 A 0 Z 117851	499 000	62	000000	000000	000000	000000	000000	000000
			63	000000	000000	000000	000000	000000	000000
			64	000000	000000	000000	000000	000000	000000
			65	000000	000000	000000	000000	000000	000000
			66	000000	000000	000000	000000	000000	000000
			67	000000	000000	000000	000000	000000	000000
			68	000000	000000	000000	000000	000000	000000
			69	000000	000000	000000	000000	000000	000000
			70	000000	000000	000000	000000	000000	000000
			71	000000	000000	000000	000000	000000	000000
			72	000000	000000	000000	000000	000000	000000
			73	000000	000000	000000	000000	000000	000000
			74	000000	000000	000000	000000	000000	000000
			75	000000	000000	000000	000000	000000	000000
			76	000000	000000	000000	000000	000000	000000
			77	000000	000000	000000	000000	000000	000000
			78	000000	000000	000000	000000	000000	000000
			79	000000	000000	000000	000000	000000	000000
			80	000000	000000	000000	000000	000000	000000
			81	000000	000000	000000	000000	000000	000000
			82	000000	000000	000000	000000	000000	000000
			83	000000	000000	000000	000000	000000	000000
			84	000000	000000	000000	000000	000000	000000
			85	000000	000000	000000	000000	000000	000000
			86	000000	000000	000000	000000	000000	000000
			87	000000	000000	000000	000000	000000	000000
			88	000000	000000	000000	000000	000000	000000
			89	000000	000000	000000	000000	000000	000000
			90	000000	000000	000000	000000	000000	000000
			91	000000	000000	000000	000000	000000	000000
			92	000000	000000	000000	000000	000000	000000
			93	000000	000000	000000	000000	000000	000000
			94	000000	000000	000000	000000	000000	000000
			95	000000	000000	000000	000000	000000	000000
			96	000000	000000	000000	000000	000000	000000
			97	000000	000000	000000	000000	000000	000000
			98	000000	000000	000000	000000	000000	000000
			99	000000	000000	000000	000000	000000	000000
			100	000000	000000	000000	000000	000000	000000

100192 1753 890 135 421 00 4424 A	4904 6611
100193 1702 748 191 440 00 5321 A	5504 6611
100198 1676 755 193 230 10 4932 A	1803 6611
100214 1664 735 278 337 00 1136 A	3003 6611
100223 1649 628 401 440 00 14342 A	6505 6611
100210 1732 773 416 405 10 15601 A	6506 6611
100212 1676 775 109 364 C 2322 A	2501 6611

[illegible]

100298 1718	941	416	464	10	3448	A	4012 6611 13
100296 1664	914	413	365	00	13405	A	2702 6611 17
100295 1697	642	254	100	00	10914	A	6407 6611 2
100294 1545	795	289	145	20	12579	A	1701 6611 49
100266 1676	543	247	360	11	9088	A	4509 6611 30
100261 1641	707	367	467	00	15650	A	6407 6611
100245 1949	934	326	184	10	3134	A	4504 6611 15

100404 1621 745 207 246 00 10722 A	2832 4611 32
100431 1707 753 210 329 00 12759 A	2739 6611 39
100432 1702 745 236 370 10 4745 A	4209 6611 24
100443 1649 719 290 362 00 4510 A	4207 6611 24
100453 1605 659 175 321 10 2417 A	2405 6611 42
100465 1714 313 241 374 00 13007 A	2513 6611 40
100480 1676 676 268 361 17 2421 A	1135 6611 31

100651 1554	512	135	293	10	4371	A	4701 6611 13
100626 1773	719	417	455	00	9915	A	6409 6611 2
100563 1621	740	177	240	22	9413	A	3504 6611 31
100551 1441	314	399	431	00	727	A	2795 6611 39
100513 1714	683	261	176	10	4587	A	3608 6611 25
100590 1702	779	363	436	00	12532	A	4410 6611 17
100665 1681	293	230	419	02	194	A	4509 6611 19

100812 1481	359	338	266	00	0502	A	2437 6611 14
100790 1476	357	318	170	00	1204	A	1703 6611 23
100740 1413	638	295	174	00	1356	A	4634 6611 19
100727 1603	790	140	194	20	1276	A	1935 6611 44
100712 1431	587	364	452	00	4312	A	4604 6611 20
100671 1595	540	251	327	10	5105	A	4312 6611 22
100665 1702	444	320	170	10	10602	A	2411 6611 16

100995 1626	693	195	100 27	4609 A	1606 6611 30
100941 1676	696	402	515 10	3651 A	4734 6611 14
100977 1600	640	279	361 00	16072 A	4531 6611 21
100975 1697	538	149	424 03	4569 A	4711 6611 10
100972 1595	807	266	109 03	3228 A	4603 6611 20
100949 1697	762	346	456 13	10219 A	5506 6611 6
100915 1783	679	423	556 00	8675 A	5113 6611 10

[illegible]

101030 1626 738 228 108 12 10900 A	2907 6411 17
101025 1753 1039 148 424 00 1521 A	2407 6411 35
101015 1641 801 248 268 22 15245 A	2508 6411 33
100963 1671 581 207 288 00 13515 A	2604 6411 40
100956 1631 709 240 230 00 4601 A	4106 6411 25
100924 1748 773 271 175 12 9490 A	1008 6411 11
100914 1671 762 220 711 10 15404 A	1703 6411 20

[illegible]

101176 1758	241	343	475	00	11437 A	5011 6611 14
101152 1676	211	243	320	02	14730 A	4703 6611 16
101094 1664	861	415	502	10	470 A	5005 6611 16
101074 1732	674	350	411	20	13557 A	4004 6611 17
101072 1631	477	272	351	02	4220 A	2004 6611 35
101063 1697	640	259	337	22	8349 A	1503 6611 31
101053 1707	714	324	426	00	14306 A	4603 6611 23

101202 1758 735 324 419 13 10845 A	4109 6611 25
101213 1664 702 347 436 23 2755 A	3309 6611 13
101233 1754 834 408 475 10 11651 A	5104 6611 9
101237 1664 642 253 292 10 12157 A	1710 6611 27
101241 1676 437 257 360 23 14545 A	2411 6611 34
101244 1664 849 283 283 33 5346 A	2333 6611 34
101292 1753 361 393 444 13 936 A	4534 6611 21

[illegible]

101294 1707 771 312 174 00 5331 A	5007 6611 16
101307 1776 752 301 368 10 13701 A	3512 6611 30
101313 1685 1179 229 297 00 1958 A	2010 6611 44
101341 1707 770 366 451 10 1543 A	5503 6611 5
101365 1441 1127 371 444 13 6263 A	4105 6611 23
101375 1722 416 330 232 02 1409 A	4211 6611 31
101412 1826 635 180 385 00 171 A	3104 6611 10

[illegible]

101430 1702 949 299 340 22 3446 A	4733 6611 19
101451 1505 600 175 291 10 6457 A	4512 6611 30
101453 1754 919 300 351 03 9665 A	5011 6611 15
101461 1613 812 217 293 10 13832 A	4709 6611 19
101465 1732 849 261 354 03 2030 A	2235 6611 41
101471 1732 749 178 420 09 2943 A	6533 6611 1
101477 1732 840 269 392 00 13403 A	4733 6611 19

[illegible]

101535 1690 724 266 432 00 13728 A	5210 6611 14
101576 1714 134 346 430 10 0698 A	4611 6611 20
101534 1671 447 249 318 20 0618 A	4106 6611 34
101509 1727 252 353 408 00 12566 A	5937 6611 2
101502 1924 1167 429 506 00 8129 A	4704 6611 17
101484 1691 404 333 396 10 1546 A	4104 6611 25
101443 1702 754 264 334 00 14111 A	2304 6611 40

[illegible]

101677 1613	703	288	429 00	805 A	2401 6611 43
101730 1697	777	369	489 00	734 A	1933 6611 26
101737 1924	944	445	532 11 12142	A	4002 6611 4
220001 1605	935	296	322 20	9180 A	5011 6611 15
220004 1676	785	275	474 10	9437 A	4209 6611 24
220016 1651	740	429	302 00	5665 A	5012 6611 15
220017 1748	849	269	304 00	4163 A	4011 6611 26

66 A 4 2 12165	400 002	61	000000	10110111	10010011	0	0	0	0
		62	000000	10110111	000000	0	0	0	0
		63	000000	10110111	000000	0	0	0	0
		64	000000	10110111	000000	0	0	0	0
		65	000000	10110111	000000	0	0	0	0
		66	000000	10110111	000000	0	0	0	0
		67	000000	10110111	000000	0	0	0	0
		68	000000	10110111	000000	0	0	0	0
		69	000000	10110111	000000	0	0	0	0
		70	000000	10110111	000000	0	0	0	0
		71	000000	10110111	000000	0	0	0	0
		72	000000	10110111	000000	0	0	0	0
		73	000000	10110111	000000	0	0	0	0
		74	000000	10110111	000000	0	0	0	0
		75	000000	10110111	000000	0	0	0	0
		76	000000	10110111	000000	0	0	0	0
		77	000000	10110111	000000	0	0	0	0
		78	000000	10110111	000000	0	0	0	0
		79	000000	10110111	000000	0	0	0	0
		80	000000	10110111	000000	0	0	0	0
		81	000000	10110111	000000	0	0	0	0
		82	000000	10110111	000000	0	0	0	0
		83	000000	10110111	000000	0	0	0	0
		84	000000	10110111	000000	0	0	0	0
		85	000000	10110111	000000	0	0	0	0
		86	000000	10110111	000000	0	0	0	0
		87	000000	10110111	000000	0	0	0	0
		88	000000	10110111	000000	0	0	0	0
		89	000000	10110111	000000	0	0	0	0
		90	000000	10110111	000000	0	0	0	0
		91	000000	10110111	000000	0	0	0	0
		92	000000	10110111	000000	0	0	0	0
		93	000000	10110111	000000	0	0	0	0
		94	000000	10110111	000000	0	0	0	0
		95	000000	10110111	000000	0	0	0	0
		96	000000	10110111	000000	0	0	0	0
		97	000000	10110111	000000	0	0	0	0
		98	000000	10110111	000000	0	0	0	0
		99	000000	10110111	000000	0	0	0	0
		100	000000	10110111	000000	0	0	0	0

200017 1748	549	249	101 00	4167 A	4011 6611 26
200014 1451	749	329	102 01	5465 A	5012 6611 15
200004 1476	785	275	164 10	9497 A	4009 6611 24
200001 1605	935	296	122 20	9186 A	5011 6611 15
101737 1424	944	445	532 11	12142 A	4002 6611 4
101730 1497	777	349	409 00	734 A	1009 6611 26
101677 1413	793	284	429 00	407 A	2401 6611 40

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	5
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	---

08

200249 1703 706 470 466 00 323 A	1612 6611 29
200276 1753 422 294 368 20 10754 A	4504 6611 21
200363 1765 540 340 407 02 2076 A	4203 6611 24
200394 1621 216 295 781 01 15641 A	2604 6611 27
200323 1613 219 220 203 00 8402 A	4704 6611 19
200022 1646 742 112 144 00 2146 A	4605 6611
200018 1549 658 311 324 00 7644 A	4704 6611 13

200107 1646	679	245	463 21	15644 A	4507 6411 21
200132 1707	722	414	492 00	4251 A	5604 6411 10
200134 1740	675	236	410 00	5770 A	2611 6411 11
200123 1641	865	257	356 00	2602 A	1906 6411 47
200102 1638	670	218	170 00	4052 A	4710 6411 19
200007 1589	562	224	267 00	15533 A	3307 6411 42
200320 1595	616	275	143 00	2477 A	4301 6411 23

[illegible]

220193 1707	694	244	341 00	5896	A	4212 6411 11
220193 1714	757	273	324 00	2379	A	7912 6411 17
220178 1702	677	300	431 11	12511	A	3509 6411 11
220177 1403	663	393	441 02	5625	A	4505 6411 14
220174 1773	945	134	394 10	13141	A	4505 6411 21
220154 1702	725	145	461 00	8343	A	5007 6411 16
220153 1404	740	149	246 10	15075	A	4504 6411 23

[illegible]

200199 1562 556 136 229 23 9319 A	2002 6611 36
200196 1561 729 167 246 00 5413 A	2409 6611 42
200198 1759 706 347 447 00 5459 A	5131 6611 14
200204 1671 694 166 227 12 12765 A	1704 6611 27
200207 1754 704 293 249 00 12973 A	4136 6611 20
200219 1631 690 197 247 02 3014 A	2031 6611 37
200274 1749 716 298 316 10 4355 A	1533 6611 24

[illegible]

200296 1779 674 444 591 00 5490 A	4601 6611 20
200291 1671 592 131 372 10 6675 A	4613 6611 20
200295 1791 734 372 511 00 5508 A	5509 6611 11
200276 1740 671 331 146 00 14081 A	2506 6611 41
200266 1714 402 277 433 00 8061 A	4105 6611 25
200252 1753 701 295 434 00 10672 A	1705 6611 29
200224 1707 458 312 325 00 10116 A	4302 6611 23

[illegible]

200333 1664 722 760 446 10 7900 A	4513 6411 15
200327 1540 657 214 790 00 2293 A	2513 6411 35
200319 1773 629 334 493 10 5140 A	4506 6411 21
200318 1638 524 372 418 02 9186 A	5101 6411 15
200314 1644 511 261 346 00 3876 A	4702 6411 19
200311 1546 540 741 432 00 10809 A	4105 6411 25
200306 1656 779 318 372 00 10240 A	3705 6411 24

910011 7 5 1 0961

201 1 5 2 1 1000

55 A 4 2 125321

20 A 4 2 106745

50 A 2 107087

105 A 4 2 117437

9 A) 2 127967

200318 1513 547 271 363 10 2176 A
 100309 1575 589 263 319 00 11405 A
 200374 1581 799 719 426 10 11596 A
 200369 1740 943 371 453 00 14444 A
 200367 1513 562 257 292 12 15651 A
 200365 1554 804 290 171 20 4577 A
 200352 1599 640 371 457 00 2166 A
 4905 6611 18
 1701 6611 25
 4539 6611 21
 2605 6611 20
 5007 6611 16
 1404 6611 24
 4513 6611 10

300229 1714 644 288 327 00 12409 A	4407 6611 21
300229 1691 760 350 707 10 14647 A	5408 6611 13
300225 1605 515 162 228 00 14263 A	2711 6611 33
300217 1580 466 262 325 10 4608 A	2310 6611 47
300142 1520 474 264 313 02 5571 A	4202 6611 23
300036 1649 727 192 260 10 3646 A	3109 6611 31
300028 1624 412 265 357 20 3724 A	4712 6611 14

[illegible]

09

300157 1722	261	283	372 02	423 A	3610 6611 23
300155 1959	407	430	507 00	5670 A	4706 6611 19
300297 1758	654	370	484 00	1347 A	4707 6611 19
300255 1630	407	171	248 20	481 A	2309 6611 30
300240 1554	747	258	300 00	11599 A	4805 6611 18
300238 1621	470	249	198 01	245 A	4205 6611 24
300232 1765	726	460	577 00	4458 A	6203 6611 2

[illegible]

300487 1651 744 248 282 12 12682 A	7605 6611 33 117
300483 1603 710 252 311 00 7732 A	1704 6611 29 260
300482 1527 618 126 229 20 11196 A	1610 6611 29 226
300460 1732 704 429 456 00 9672 A	5801 6611 2 17
300415 1676 847 116 417 00 13933 A	4306 6611 26 571
300411 1740 649 174 457 10 367 A	4602 6611 23 123
300396 1722 754 325 348 00 10741 A	5406 6611 13 62

[illegible]

300449 1671 272 240 260 00 4001 A	1709 6611 13
300599 1646 557 148 311 10 15575 A	2309 6609 43
300566 1740 210 403 517 00 13851 A	4309 6611 21
300564 1611 473 220 281 00 15686 A	2301 6611 17
300540 1774 653 293 424 23 9571 A	4701 6611 19
300505 1575 545 324 340 00 9520 A	4505 6611 20
300498 1541 728 220 282 00 12757 A	1705 6611 40

[illegible]

300654	1773	719	195	274	10	15066	A	2439	6611	42	63	1
330583	1707	642	244	207	13	646	A	3731	6611	25	837	1
330699	1576	435	252	332	10	12253	A	4235	6611	24	158	1
330704	1481	726	352	444	33	13176	A	5904	6611	14	41	1
330732	1613	612	165	209	23	10679	A	4736	6611	14	100	1
330744	1664	721	275	333	13	2614	A	3736	6611	27	751	1
330751	1656	572	216	142	33	4171	A	2601	6611	18	247	1

[illegible]

300857	1500	547	242	126	20	1204	A
300867	1758	949	463	502	13	6468	A
300977	1829	957	338	461	00	14539	A
300880	1676	703	448	461	00	7544	A
300890	1702	946	243	316	00	545	A
300899	1494	433	145	124	20	636	A
300925	1707	757	301	407	10	169	A

[illegible]

331044 1526 569 238 245 00 1843 A	2806 6411 31 344
331943 1478 535 215 263 00 14697 A	4411 6411 21 334
331338 1575 721 250 265 20 12053 A	4003 6411 25 214
331221 1638 717 215 313 20 1313 A	2603 6411 24 586
330945 1587 476 144 230 20 2747 A	2101 6411 40 99
330947 1689 565 327 331 13 14023 A	4306 6411 21 1101
330936 1749 462 427 489 10 14611 A	4701 6411 19 223

[illegible]

301092 1714	789	328	399	10	2057	A	4701 6611 19
301092 1600	669	219	292	00	14515	A	4710 6611 22
301079 1727	987	254	323	22	9966	A	2704 6609 39
301076 1651	929	144	283	00	13250	A	1905 6609 42
301068 1702	730	349	440	02	1155	A	4707 6611 19
301053 1664	719	239	343	10	1806	A	4612 6611 19
300045 1639	526	236	322	00	15524	A	4004 6611 25

301104 1646 219 211 274 00 13110 A	301104 1646 219 211 274 00 13110 A
301143 1660 210 283 175 00 6589 A	301143 1660 210 283 175 00 6589 A
301140 1753 614 246 407 00 340 A	301140 1753 614 246 407 00 340 A
301132 1676 752 234 242 00 13473 A	301132 1676 752 234 242 00 13473 A
301110 1651 704 153 410 00 15064 A	301110 1651 704 153 410 00 15064 A
301102 1714 692 750 412 00 12472 A	301102 1714 692 750 412 00 12472 A
301097 1822 1043 401 525 00 15008 A	301097 1822 1043 401 525 00 15008 A

[illegible]

101230 1685 606 412 436 00 11760 A	4306 6611 31
101220 1685 606 225 266 10 7794 A	4306 6611 32
101190 1575 553 210 256 10 12414 A	4203 6611 24
101189 1679 713 259 319 10 3056 A	2908 6611 31
101171 1547 647 170 240 02 2650 A	2705 6611 30
101147 1758 431 465 554 00 7953 A	6203 6611 3
101146 1714 908 196 285 00 6594 A	2705 6611 34

[illegible]

101277 1524	544	240	285	23	0044	A	4472 6611 17
101276 1727	466	444	542	00	10247	A	4609 6611 23
101269 1580	648	202	107	10	4130	A	2101 6611 40
101259 1702	760	132	251	00	14349	A	1609 6611 10
101258 1511	489	245	299	00	10677	A	5309 6611 13
101238 1400	653	262	308	03	9406	A	4601 6611 23
101232 1664	554	269	302	00	14378	A	2706 6611 12

[illegible]

701340 1727	838	304	424	00	1552	A	2212 6611 43	457	1
701324 1697	916	283	485	10	2132	A	4208 6611 24	134	1
701321 1651	719	304	382	00	1591	A	1703 6611 29	94	1
701319 1612	665	259	370	00	816	A	4211 6611 23	325	1
701311 1691	748	236	318	10	8885	A	2408 6611 19	613	1
701303 1714	665	296	370	13	795	A	3401 6611 30	904	1
701300 1651	621	338	366	00	6941	A	2409 6611 38	1159	1

[illegible]

301447 1778 866 251 461 00 15005 A	2905 6611 29	98
301446 1732 706 220 336 00 4023 A	2907 6611 37	2965
301414 1638 615 258 320 00 9973 A	3207 6611 29	815
301411 1727 900 285 385 00 10506 A	4601 6611 20	29
301386 1638 894 347 406 00 2999 A	4604 6611 20	32
301380 1783 856 384 437 00 7067 A	4308 6611 23	151
301353 1613 938 185 205 02 716 A	2806 6611 35	548

[illegible]

301543 1727 915 236 291 10 12371 A	2205 6611 44
301545 1714 513 274 343 00 2950 A	1504 6611 31
301559 1595 541 143 214 22 15680 A	1210 6611 43
301569 1753 703 408 468 12 242 A	5006 6611 15
301575 1714 424 290 365 02 7913 A	4806 6611 18
301591 1654 692 243 424 02 3907 A	4506 6611 20
301613 1697 633 241 322 10 14232 A	2606 6611 30

[illegible]

101558 1578	663	220	102 00	735 A	1612 6611 31	404 T
101657 1626	576	177	246 10	7361 A	1606 6611 30	953 T
101655 1613	795	265	105 12	4090 A	1405 6611 32	290 T
101649 1637	646	314	395 00	12109 A	2301 6611 43	366 T
101647 1626	689	254	327 00	12743 A	2410 6611 39	380 T
101643 1575	804	219	276 20	10335 A	4305 6611 22	194 T
101541 1702	767	192	352 20	15472 A	2302 6611 26	49 T

[illegible]

101664 1671 720 235 106 00 15055 A	1936 6611 41 278 T
301703 1621 743 306 264 00 2748 A	4204 6611 23 224
301726 1664 719 271 310 10 600 A	4838 6611 17 305
301736 1626 753 248 303 00 14321 A	2901 6611 27 324
401755 1554 517 336 340 00 4693 A	4809 6611 16 58
401759 1641 426 236 111 00 1151 A	3727 6611 29 16
501816 1405 599 169 225 10 13222 A	5038 6611 34 725

[illegible]

101961 1707 785 311 407 00 5342 A	7631 6411 74
101345 1714 644 332 366 00 6491 A	4309 6411 15
101444 1618 762 193 272 20 10795 A	7635 6411 30
101433 1426 551 219 104 20 12206 A	7635 6411 12
101435 1638 577 184 276 20 9539 A	2130 6411 15
101422 1562 536 242 124 02 15647 A	4309 6411 34
101419 1464 558 204 242 00 3436 A	2201 6411 40

[illegible]

301951 1714	741	400	455 13 14659 A	4338 6611 14	37
301946 1491	713	274	150 10 4329 A	3826 6611 13	19
301935 1751	717	319	104 03 4745 A	4912 6611 16	263
301902 1748	456	335	441 00 4485 A	4927 6611 16	42
301899 1444	619	297	767 00 12760 A	1707 6611 24	159
301890 1722	745	266	438 00 13626 A	2639 6611 40	374
301869 1651	713	302	401 10 4477 A	4234 6611 23	56

[illegible]

301940 1680 601 302 367 00 1673 A	5106 6011 11	02 1
332305 1426 694 248 294 00 15123 A	2702 6411 29	591
132324 1587 739 214 294 03 2207 A *	1613 6611 29	202
332326 1634 733 238 240 10 4059 A	4205 6611 24	116
132349 1656 653 305 302 10 2441 A	4534 6611 21	48
102050 1707 503 202 254 00 4205 A	2007 6611 43	2347
132092 1824 671 291 304 00 12561 A	2405 6611 49	165

[illegible]

302179	1676	735	244	325	10	4790	A	0601 6611 20
302163	1638	580	315	304	00	5153	A	0512 6611 10
302150	1651	713	197	285	00	13754	A	4309 6611 25
302156	1732	749	324	342	00	2826	A	4304 6611 23
302130	1573	719	218	242	00	2864	A	1609 6611 10
302126	1664	925	242	272	00	15612	A	2906 6611 36
302101	1575	622	264	407	00	11324	A	1710 6611 29

[illegible]

oil

400042 1526 526 107 129 00 12641 A	400042 1526 526 107 129 00 12641 A
400040 1641 647 310 36 00 14628 A	400040 1641 647 310 36 00 14628 A
400038 1505 609 315 349 00 12150 A	400038 1505 609 315 349 00 12150 A
400017 1580 542 245 274 00 12070 A	400017 1580 542 245 274 00 12070 A
400005 1413 474 260 201 22 10127 A	400005 1413 474 260 201 22 10127 A
402335 1431 731 251 297 00 8014 A	402335 1431 731 251 297 00 8014 A
404325 1714 740 222 324 22 114 A	404325 1714 740 222 324 22 114 A
4013 6411 29	4013 6411 29
4005 6411 27	4005 6411 27
4213 6411 23	4213 6411 23
1606 6411 49	1606 6411 49
4710 6411 19	4710 6411 19
7101 6411 35	7101 6411 35
8202 6411 24	8202 6411 24

[illegible]

111

400124 1765 776 186 937 00 342 A	6137 6411 3
400122 1791 928 172 415 00 762 A	5010 6411 16
400114 1641 644 174 421 00 6797 A	5610 6411 11
400106 1714 1023 151 194 10 1230 A	4011 6411 17
400041 1714 624 208 399 00 67 A	4911 6411 17
400053 1549 549 243 203 00 1470 A	4937 6411 27
400050 1540 545 104 154 00 13901 A	4701 6411 10

[illegible]

400182 1571	479	247	137	10	15057	A	3507 6611 31
400164 1664	705	957	422	10	2374	A	4107 6611 4
400159 1524	680	243	117	10	10694	A	2705 6611 34
400154 1518	599	277	762	00	3432	A	4704 6611 19
400144 1554	494	292	105	00	11830	A	3907 6611 27
400142 1549	541	217	245	02	13473	A	3005 6611 30
400143 1481	492	221	293	23	574	A	2505 6611 36

[illegible]

400221 1740	444	240	091 00	296 A	4005 6411 27
400220 1716	701	285	344 00	11932 A	4005 6411 27
400219 1803	445	418	517 00	1286 A	4005 6411 16
400218 1727	541	432	511 00	14114 A	4005 6411 1
400205 1908	441	400	569 00	5269 A	4005 6411 16
400199 1441	763	362	445 00	4595 A	4005 6411 5
400191 1803	742	415	429 02	10794 A	4005 6411 18

[illegible]

400317	1773	461	376	487	10	10432	A	5135	6611	15	102	T
400309	1765	1051	344	437	10	2774	A	3907	6611	22	76	T
400101	1576	792	289	387	00	1045	A	2902	6611	38	480	T
400276	1664	770	307	403	10	14265	A	1336	6611	27	191	T
400246	1495	687	337	404	10	13272	A	5210	6611	14	94	T
400234	1651	626	224	267	03	8072	A	1607	6611	50	545	T
400224	1459	919	434	534	12	3700	A	5210	6611	A	27	T

[illegible]

400320 1600 671 225 082 13 15278 A	2105 6611 41	131 B
400327 1656 576 368 499 12 3591 A	6107 6611 5	24 B
400346 1718 648 179 234 00 9062 A	2805 6611 29	116 B
400349 1678 658 194 296 20 6792 A	4901 6611 17	119 B
400371 1646 699 279 139 00 1623 A	4410 6611 22	117 B
400380 1727 730 283 404 00 7199 A	4908 6611 17	115 B
400393 1732 790 211 282 00 2707 A	2306 6611 19	602 B

[illegible]

400457 1765 57M 214 442 00 44977 A	5010 6611 16
400429 1676 754 303 397 00 4155 A	6110 6611 5
400409 1626 695 187 314 12 3576 A	4107 6611 23
400404 1456 566 216 286 20 12716 A	3006 6611 27
400401 1751 749 342 490 22 12746 A	5510 6611 11
400400 1753 857 330 499 10 201 A	5210 6611 14
400385 1759 992 254 322 00 11132 A	1607 6611 44

[illegible]

500093 1732 505 322 421 00 1445 A	6511 6611 1
500079 1748 303 394 491 00 10824 A	5105 6611 13
500072 1631 674 443 504 00 4414 A	6511 6611 1
500064 1613 545 244 324 00 13763 A	6511 6611 1
500043 1613 517 245 393 10 8286 A	6511 6611 1
500014 1803 755 389 444 00 3509 A	6511 6611 1
500004 1646 671 329 395 10 9364 A	6511 6611 1

[illegible]

[illegible]

500132	1664	7M0	210	101	00	11045	A	6511	6611	1	7
500138	1714	473	350	475	00	166	A	6511	6611	1	2
500140	1676	699	390	487	00	7795	A	6511	6609		2
500159	1707	880	397	474	00	10617	A	6511	6611	1	2
500179	1727	821	106	414	00	738	A	6511	6611	1	6
500193	1605	712	266	317	10	15274	A	6511	6611	1	
500200	1714	720	318	390	00	11194	A	6511	6611	1	2

[illegible]

500248 1626 744 317 341 00 14779 A	6511 6611 1
500244 1727 849 319 401 10 3048 A	6511 6611 1
500237 1697 603 285 352 10 5662 A	6511 6611 1
500226 1651 685 276 348 00 9668 A	6511 6611 1
500215 1773 679 303 327 10 12674 A	6511 6611 1
500212 1626 635 219 296 00 4050 A	6511 6611 1
500203 1656 707 375 457 20 13357 A	6511 6611 1

[illegible]

500297 1791 714 507 600 10 0765 A	6511 6611 1
500291 1626 650 299 749 00 315 A	6511 6611 1
500293 1803 1082 413 463 00 1954 A	6511 6611 1
500288 1773 709 301 451 00 14504 A	6511 6611 1
500276 1638 628 284 361 20 13971 A	6511 6611 1
500258 1732 911 381 490 00 12931 A	6511 6611 1
500252 1638 605 141 216 10 15649 A	6511 6611 1

[illegible]

600312	1547	655	108	207	10	10445	A	4604	6611	20
600025	1651	615	297	430	10	13735	A	5507	6611	11
600013	1641	644	289	705	07	1236	A	4607	6611	17
600002	1791	654	150	502	09	4107	A	5509	6611	5
500344	1651	658	214	262	02	6504	A	6511	6611	1
500344	1753	740	370	452	00	219	A	6511	6611	1
500309	1714	658	367	417	00	1062	A	6511	6611	1

[illegible]

600047 1740	630	319	402 20	1073 A	4505 6611 20
600058 1749	794	323	406 00	4701 A	5734 6611 3
600064 1748	717	420	419 00	11026 A	5701 6611 9
600059 1699	674	171	521 00	5583 A	6105 6611 4
600056 1621	813	257	397 10	12112 A	4505 6611 20
600047 1621	583	325	470 02	409 A	5209 6611 14
600033 1714	692	219	190 10	4550 A	5103 6611 15

[illegible]

500136 1651	339	266	216 00 11176	A	4505 6611
600137 1668	782	242	212 11	4452 A	4505 6611
600127 1727	622	319	439 00 15129	A	5501 6611
600119 1656	976	284	764 00	4249 A	4605 6611
600105 1759	562	347	377 02	1971 A	5510 6611
600097 1664	717	710	373 00	4955 A	4507 6611
600099 1600	440	195	277 02 10419	A	4704 6611

[illegible]

500139 1732 798 290 141 00 11995 A	500145 1714 719 318 374 10 7414 A	450147 1656 528 250 323 00 13618 A	4604 6611 20 6125 A	500150 1554 642 218 276 20 6125 A	500154 1544 728 293 317 00 2964 A	4511 6611 21 5732 6611 A	600157 1656 231 160 456 12 4204 A	700204 1400 780 455 531 00 4285 A
111 T	501 T	160 T	612 T	601 T	57 T	81 T	13 T	

[illegible]

700044 1664 674 134 190 00 4003 A	5405 6411
700052 1714 634 140 480 00 15627 A	5704 6411
700071 1816 698 140 454 01 2871 A	5727 6411
700044 1664 794 730 294 03 11441 A	5806 6411
700120 1631 643 356 187 00 4767 A	5629 6411
700147 1575 500 247 112 00 4800 A	5701 6411
700167 1689 855 247 354 00 3904 A	5407 6411

[illegible]

700165	1702	957	916	467	10	12461	A	5704	6611	9	18	1
700220	1656	635	394	456	00	12555	A	6004	6611	6	19	1
700253	1656	711	296	161	03	4264	A	5407	6611	11	42	1
700264	1704	700	250	386	12	9667	A	5404	6611	4	55	1
700280	1791	654	430	554	03	11671	A	5904	6611	4	17	1
700284	1671	719	240	357	03	4026	A	5404	6611	13	20	1
700294	1545	766	313	391	03	5534	A	6011	6611	5	12	1

[illegible]

700496 1451	413	244	00	12225	A	5403 6411	4	55	
700466 1476	349	233	325	10	909	A	5407 6411	10	20
700442 1491	325	304	170	00	5433	A	5407 6411	10	20
700461 1722	426	351	401	22	7683	A	5413 6411	8	45
700454 1753	667	455	512	10	3461	A	5404 6411	12	6
700436 1476	744	393	481	10	8265	A	5413 6411	7	14
700433 1722	417	243	370	00	13265	A	5403 6411	12	25

OCI

800020 1253 773 415 483 01 8803 A	5605 6611 10
800020 1676 472 314 366 11 1634 A	5805 6611 10
800019 1416 812 404 517 10 15672 A	5605 6611 10
800022 1546 536 284 367 11 3376 A	5805 6611 10
700609 1437 726 347 445 00 12401 A	5805 6611 12
700551 1753 671 375 459 12 15242 A	5807 6611 10
700649 1714 647 371 508 00 12170 A	5611 6611 10

900152 1707 911 394 440 00 3700 A	5705 6611 10
900141 1702 463 426 520 00 13703 A	5701 6611 9
900117 1441 559 423 523 10 11763 A	5702 6611 7
900104 1434 707 228 303 10 1207 A	5710 6611 9
900056 1758 745 362 467 00 15656 A	5710 6611 9
900032 1476 642 352 392 00 13723 A	5711 6611 9
900025 1451 749 274 365 00 706 A	5705 6611 6

900116 1702	907 289	361 10 15177 A	4611 6611 22
900106 1671	950 217	769 00 4094 A	4709 6611 19
900103 1646	674 162	220 20 3520 A	4710 6611 17
900098 1605	729 385	193 11 4330 A	4509 6611 20
900089 1529	899 223	262 22 5711 A	4309 6611 23
900077 1591	659 253	409 10 7657 A	4709 6611 19
900074 1732	749 327	406 00 5056 A	4511 6611 21

900116 1702	907	299	361 10 15177 A	4411 6611 22
900105 1671	950	217	269 00 4098 A	4709 6611 17
900103 1646	674	167	220 20 3530 A	4710 6611 17
900098 1605	729	335	193 11 4330 A	4509 6611 20
900089 1527	999	223	282 22 5711 A	4708 6611 21
900077 1591	658	253	408 10 7657 A	4709 6611 19
900074 1732	744	327	406 00 8056 A	4511 6611 21

900120 1765 ' 611 2 16 101 23 4563 A	4005 6611 26 2016 T
900125 1626 947 96 205 22 8082 A	4009 6611 26 1401 T
900126 1697 953 397 499 20 11207 A	4005 6611 17 125 T

COHORT "A"

"Less-than-normals": Dead

pp. 136 - 151

403359	1712	907	285	107	00	4120	D	71	151	1009	6411	27
331047	1626	653	292	379	00	4040	D	71	151	3209	6411	32
200373	1793	630	255	454	00	13066	D	76	151	3009	6411	36
500261	1651	525	319	362	10	HM19	D	69	153	6511	6411	1
332306	1456	672	196	318	10	10205	D	72	144	4009	6411	26
500190	1562	565	261	341	11	6078	D	75		5511	6411	1
101170	1792	459	170	273	00	14793	D	70		2404	6411	32

[illegible]

40156	1638	563	256	316	22	10423	0	75	163	3811	6611	27
900070	1714	841	286	152	01	15643	0	73	162	4713	6611	19
600304	1575	572	211	276	23	9774	0	72	162	4732	6611	13
400282	1600	674	308	342	00	6782	0	74	162	3931	6611	27
400083	1681	657	262	100	00	11152	0	73	162	2912	6611	32
101132	1651	613	204	295	00	1139	0	73	162	3738	6611	29
200300	1678	583	253	326	10	11084	0	69	162	4239	6611	24

[illegible]

400140	1551	730	261	104	00	3422	0	73	177	1312	6611	36	210	1
300937	1676	494	192	764	00	11512	0	70	177	2301	6611	37	350	1
400030	1639	705	197	716	00	12050	0	75	163	2707	6611	31	767	1
300451	1676	457	241	402	00	13798	0	74	163	2919	6611	46	238	1
300253	1597	726	148	245	20	9724	0	74	153	1609	6611	30	746	1
100966	1537	558	175	263	10	3226	0	74	163	2711	6611	24	77	A
40164	1419	525	221	273	00	14162	0	74	163	1307	6611	43	619	1

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

40212 1791 241 354 401 20 1206 17 75 420 1904 6611 22
 90144 1637 767 214 752 00 12193 19 63 423 2404 6611 41
 90046 1621 696 145 214 12 8928 19 71 420 1703 6611 33
 10564 1740 1902 354 422 00 4070 19 71 420 1703 6611 9
 101524 1513 643 227 241 10 1443 19 71 412 2310 6611 43
 101346 1651 694 234 242 00 7423 19 71 410 4111 6611 25
 10096 1400 755 236 247 00 781 19 71 356 1302 6611 14

[illegible]

471

100745	1446	716	134	257	20	2520	0	75	420	4110	6411	23
100725	1562	982	136	247	20	11450	0	74	420	2404	6411	26
100527	1613	496	207	420	00	6953	0	73	420	4102	6411	23
100146	1614	735	122	193	00	12740	0	71	420	4603	6411	23
100132	1621	734	252	409	00	4540	0	75	420	4705	6411	19
100074	1531	652	166	227	10	7666	0	64	420	2411	6411	41
40519	1505	412	197	264	10	6352	0	75	420	1403	6411	23

[illegible]

100930	1601	714	230	144	10	133/1	0	69	423	2638	6611	29
101014	1606	717	270	120	11	10564	0	74	420	3723	6611	29
233104	1656	766	294	384	12	9232	0	73	420	2710	6611	30
230301	1613	740	155	262	22	10750	0	69	420	3513	6611	30
100326	1676	721	271	127	00	3316	0	73	423	3636	6611	30
100669	1590	551	295	741	00	2072	0	71	423	3610	6611	30
101939	1570	703	102	250	03	4414	0	69	420	2704	6611	30

[illegible]

503045 1456 403 131 232 00 5147 0 69 430 6511 6611 1

503046 1758 114 356 13 848 0 75 430 6511 6611 1

503047 1808 272 180 067 00 12947 0 75 430 6511 6611 1

503048 1597 946 302 366 10 10973 0 74 430 6511 6611 1

403332 1454 755 234 245 01 7578 0 70 430 6511 6611 40

403302 1547 671 204 256 00 9342 0 69 430 6511 6611 27

403081 1454 624 202 404 10 7747 0 70 430 6511 6611 27

[illegible]

703533 1414 416 050 12 10 695 0 72 422 2705 6611 10
 703134 1451 670 204 261 21 10204 0 75 422 1404 6611 10
 703549 1405 260 215 303 11 12581 0 72 420 5611 6611 10
 703324 1416 242 207 411 02 11587 0 75 420 5610 6611 10
 703212 1405 236 197 044 20 15638 0 72 420 5613 6611 10
 603144 1446 412 307 371 00 2601 0 75 420 4811 6611 10
 603132 1400 628 194 376 10 0912 0 75 420 4405 6611 10

[illegible]

701491 1600 649 204 271 00 10574 0 74 074 3734 6611 27

101402 1722 425 196 125 00 12420 0 74 017 4712 6611 24

600945 1722 640 400 471 12 2027 0 73 016 6504 6411 1

701491 1722 742 150 404 00 131 0 74 008 4028 6411 1

RECORD LAY-OUT: COHORT "B"

#	Length	Item, including units and "format"
1	6	Identity number
2-4	6	Date of birth (day/month/year)
5	5	Film reading sequence number
6	1	Status (Alive, Dead or Lost to view)
7	2	Year of death, or loss (blank if alive)
8	3	Cause of death * (blank if alive or lost to view)
9	4	Date of start of first job (year/month)
10	4	Date of end of last recorded job (year/month)
11	2	Net service (years: truncated) (I2)
12	5	Accumulated dust exposure (mpcf.y: truncated) (I5)
13	1	Mining area (Asbestos or Thetford Mines)
14	1	Reader (as recoded, see p. 180)
15	1	"Normal" or "Less-than-normal"
16	1	Smoking code (see p. 180)
17	43	X-ray readings (see next page)

* First character R or S for accidents at asbestos work

LAY-OUT OF X-RAY READINGS: COHORT "B"

#	Length	Print cols.	Item
1	1	59	Film quality (+; +/-; +/--)
2	9	61-63 64-69	Small rounded opacities type; profusion zones (RU; RM; RL; LU; LM; LL)
3	9	71-73 74-79	Small irregular opacities type; profusion zones (RU; RM; RL; LU; LM; LL)
4	2	81-82	Large opacities well defined; poorly defined
5	1	84	Costophrenic angle(s)
6	3	85-87	Pleural thickening diffuse; plaques; grade
7	1	89	Irregular diaphragm
8	1	91	Irregular cardiac border
9	4	93-96	Pleural calcification diaphragm; wall; other; grade
10	1	98	"Additional symbols" (count)
11	1	100	"Comments" (1 = Yes)

COHORT "B"

Reader 1

"Normals"

pp. 155 - 177

"Less-than-normals"

pp. 178 - 184

REPRODUCED
FROM
BEST AVAILABLE
COPY

10	4	4	CCCCC	CCCCC
11	5	5	CCCCC	CCCCC
12	6	6	CCCCC	CCCCC
13	7	7	CCCCC	CCCCC
14	8	8	CCCCC	CCCCC
15	9	9	CCCCC	CCCCC
16	10	10	CCCCC	CCCCC
17	11	11	CCCCC	CCCCC
18	12	12	CCCCC	CCCCC
19	13	13	CCCCC	CCCCC
20	14	14	CCCCC	CCCCC
21	15	15	CCCCC	CCCCC
22	16	16	CCCCC	CCCCC
23	17	17	CCCCC	CCCCC
24	18	18	CCCCC	CCCCC
25	19	19	CCCCC	CCCCC
26	20	20	CCCCC	CCCCC
27	21	21	CCCCC	CCCCC
28	22	22	CCCCC	CCCCC
29	23	23	CCCCC	CCCCC
30	24	24	CCCCC	CCCCC
31	25	25	CCCCC	CCCCC
32	26	26	CCCCC	CCCCC
33	27	27	CCCCC	CCCCC
34	28	28	CCCCC	CCCCC
35	29	29	CCCCC	CCCCC
36	30	30	CCCCC	CCCCC
37	31	31	CCCCC	CCCCC
38	32	32	CCCCC	CCCCC
39	33	33	CCCCC	CCCCC
40	34	34	CCCCC	CCCCC
41	35	35	CCCCC	CCCCC
42	36	36	CCCCC	CCCCC
43	37	37	CCCCC	CCCCC
44	38	38	CCCCC	CCCCC
45	39	39	CCCCC	CCCCC
46	40	40	CCCCC	CCCCC
47	41	41	CCCCC	CCCCC
48	42	42	CCCCC	CCCCC
49	43	43	CCCCC	CCCCC
50	44	44	CCCCC	CCCCC
51	45	45	CCCCC	CCCCC
52	46	46	CCCCC	CCCCC
53	47	47	CCCCC	CCCCC
54	48	48	CCCCC	CCCCC
55	49	49	CCCCC	CCCCC
56	50	50	CCCCC	CCCCC
57	51	51	CCCCC	CCCCC
58	52	52	CCCCC	CCCCC
59	53	53	CCCCC	CCCCC
60	54	54	CCCCC	CCCCC
61	55	55	CCCCC	CCCCC
62	56	56	CCCCC	CCCCC
63	57	57	CCCCC	CCCCC
64	58	58	CCCCC	CCCCC
65	59	59	CCCCC	CCCCC
66	60	60	CCCCC	CCCCC
67	61	61	CCCCC	CCCCC
68	62	62	CCCCC	CCCCC
69	63	63	CCCCC	CCCCC
70	64	64	CCCCC	CCCCC
71	65	65	CCCCC	CCCCC
72	66	66	CCCCC	CCCCC
73	67	67	CCCCC	CCCCC
74	68	68	CCCCC	CCCCC
75	69	69	CCCCC	CCCCC
76	70	70	CCCCC	CCCCC
77	71	71	CCCCC	CCCCC
78	72	72	CCCCC	CCCCC
79	73	73	CCCCC	CCCCC
80	74	74	CCCCC	CCCCC
81	75	75	CCCCC	CCCCC
82	76	76	CCCCC	CCCCC
83	77	77	CCCCC	CCCCC
84	78	78	CCCCC	CCCCC
85	79	79	CCCCC	CCCCC
86	80	80	CCCCC	CCCCC
87	81	81	CCCCC	CCCCC
88	82	82	CCCCC	CCCCC
89	83	83	CCCCC	CCCCC
90	84	84	CCCCC	CCCCC
91	85	85	CCCCC	CCCCC
92	86	86	CCCCC	CCCCC
93	87	87	CCCCC	CCCCC
94	88	88	CCCCC	CCCCC
95	89	89	CCCCC	CCCCC
96	90	90	CCCCC	CCCCC
97	91	91	CCCCC	CCCCC
98	92	92	CCCCC	CCCCC
99	93	93	CCCCC	CCCCC
100	94	94	CCCCC	CCCCC

[illegible]

[illegible]

[illegible]

1.1	0	1	00000	00000
1.2	0	1	00001	00000
1.3	0	1	00002	00000
1.4	0	1	00003	00000
1.5	0	1	00004	00000
1.6	0	1	00005	00000
1.7	0	1	00006	00000
1.8	0	1	00007	00000
1.9	0	1	00008	00000
1.10	0	1	00009	00000
1.11	0	1	00010	00000
1.12	0	1	00011	00000
1.13	0	1	00012	00000
1.14	0	1	00013	00000
1.15	0	1	00014	00000
1.16	0	1	00015	00000
1.17	0	1	00016	00000
1.18	0	1	00017	00000
1.19	0	1	00018	00000
1.20	0	1	00019	00000
1.21	0	1	00020	00000
1.22	0	1	00021	00000
1.23	0	1	00022	00000
1.24	0	1	00023	00000
1.25	0	1	00024	00000
1.26	0	1	00025	00000
1.27	0	1	00026	00000
1.28	0	1	00027	00000
1.29	0	1	00028	00000
1.30	0	1	00029	00000
1.31	0	1	00030	00000
1.32	0	1	00031	00000
1.33	0	1	00032	00000
1.34	0	1	00033	00000
1.35	0	1	00034	00000
1.36	0	1	00035	00000
1.37	0	1	00036	00000
1.38	0	1	00037	00000
1.39	0	1	00038	00000
1.40	0	1	00039	00000
1.41	0	1	00040	00000
1.42	0	1	00041	00000
1.43	0	1	00042	00000
1.44	0	1	00043	00000
1.45	0	1	00044	00000
1.46	0	1	00045	00000
1.47	0	1	00046	00000
1.48	0	1	00047	00000
1.49	0	1	00048	00000
1.50	0	1	00049	00000
1.51	0	1	00050	00000
1.52	0	1	00051	00000
1.53	0	1	00052	00000
1.54	0	1	00053	00000
1.55	0	1	00054	00000
1.56	0	1	00055	00000
1.57	0	1	00056	00000
1.58	0	1	00057	00000
1.59	0	1	00058	00000
1.60	0	1	00059	00000
1.61	0	1	00060	00000
1.62	0	1	00061	00000
1.63	0	1	00062	00000
1.64	0	1	00063	00000
1.65	0	1	00064	00000
1.66	0	1	00065	00000
1.67	0	1	00066	00000
1.68	0	1	00067	00000
1.69	0	1	00068	00000
1.70	0	1	00069	00000
1.71	0	1	00070	00000
1.72	0	1	00071	00000
1.73	0	1	00072	00000
1.74	0	1	00073	00000
1.75	0	1	00074	00000
1.76	0	1	00075	00000
1.77	0	1	00076	00000
1.78	0	1	00077	00000
1.79	0	1	00078	00000
1.80	0	1	00079	00000
1.81	0	1	00080	00000
1.82	0	1	00081	00000
1.83	0	1	00082	00000
1.84	0	1	00083	00000
1.85	0	1	00084	00000
1.86	0	1	00085	00000
1.87	0	1	00086	00000
1.88	0	1	00087	00000
1.89	0	1	00088	00000
1.90	0	1	00089	00000
1.91	0	1	00090	00000
1.92	0	1	00091	00000
1.93	0	1	00092	00000
1.94	0	1	00093	00000
1.95	0	1	00094	00000
1.96	0	1	00095	00000
1.97	0	1	00096	00000
1.98	0	1	00097	00000
1.99	0	1	00098	00000
2.00	0	1	00099	00000

0	0	0	0	000000	000000
0	0	0	1	000001	000000
0	0	1	0	000010	000000
0	0	1	1	000011	000000
0	1	0	0	000100	000000
0	1	0	1	000101	000000
0	1	1	0	000110	000000
0	1	1	1	000111	000000
1	0	0	0	001000	000000
1	0	0	1	001001	000000
1	0	1	0	001010	000000
1	0	1	1	001011	000000
1	1	0	0	001100	000000
1	1	0	1	001101	000000
1	1	1	0	001110	000000
1	1	1	1	001111	000000
0	0	0	0	010000	000000
0	0	0	1	010001	000000
0	0	1	0	010010	000000
0	0	1	1	010011	000000
0	1	0	0	010100	000000
0	1	0	1	010101	000000
0	1	1	0	010110	000000
0	1	1	1	010111	000000
1	0	0	0	011000	000000
1	0	0	1	011001	000000
1	0	1	0	011010	000000
1	0	1	1	011011	000000
1	1	0	0	011100	000000
1	1	0	1	011101	000000
1	1	1	0	011110	000000
1	1	1	1	011111	000000
0	0	0	0	100000	000000
0	0	0	1	100001	000000
0	0	1	0	100010	000000
0	0	1	1	100011	000000
0	1	0	0	100100	000000
0	1	0	1	100101	000000
0	1	1	0	100110	000000
0	1	1	1	100111	000000
1	0	0	0	101000	000000
1	0	0	1	101001	000000
1	0	1	0	101010	000000
1	0	1	1	101011	000000
1	1	0	0	101100	000000
1	1	0	1	101101	000000
1	1	1	0	101110	000000
1	1	1	1	101111	000000
0	0	0	0	110000	000000
0	0	0	1	110001	000000
0	0	1	0	110010	000000
0	0	1	1	110011	000000
0	1	0	0	110100	000000
0	1	0	1	110101	000000
0	1	1	0	110110	000000
0	1	1	1	110111	000000
1	0	0	0	111000	000000
1	0	0	1	111001	000000
1	0	1	0	111010	000000
1	0	1	1	111011	000000
1	1	0	0	111100	000000
1	1	0	1	111101	000000
1	1	1	0	111110	000000
1	1	1	1	111111	000000

[illegible]

[illegible]

155018	1 11 23	5121 5 2	4536 5 2 23	155 1 1 6 2	333333	303009	0 0 0 0
155027	1 2 16	1751 5 2	4630 5 7 2	6 1 1 1 1 1	3-333333	0-003333	0 0 0 0
155031	23 8 15	740 8 2	4259 0 11 11	26 1 1 1 1 1	333333	003333	0 0 0 0
155043	13 1 18	1672 8 0	5125 5 1 5	6 1 1 9 1	003000	303000	0 0 0 0
155079	28 5 6	1501 8 0	7636 4 7 6 11	642 1 1 7 2	333333	303333	0 0 0 0
155082	15 6 3	5111 8 2	7630 5 5 1 3	68 1 1 1 1 1	333333	303002	2 0 0 1
155016	21 6 7	551 8 2	6913 5 3 7	1 1 1 1 1 1	333333	223333	0 0 0 0
155021	13 6 12	1587 8 0	6010 5 5 1	12 1 1 1 1 2	333333	303333	0 0 0 0
155011	16 6 23	5652 8 1	3013 5 9 2 13	74 1 1 1 6 1	003333	006663	0 0 0 0
155012	29 6 18	5553 8 2	6503 6 1 5	1 1 1 1 1 2	003203	303003	0 0 0 0
155055	8 3 12	1950 8 2	9712 6 0 2	1 1 1 1 7 1	0-333333	5-303333	0 0 0 0
155062	7 13 3	1235 8 0	2500 6 5 1 1 7	150 1 1 1 2 2	333333	300003	0 0 0 0
155051	13 8 3	5650 8 0	2627 6 9 8 1	93 1 1 1 6 2	003333	000003	0 0 0 0
155022	19 1 23	3206 8 2	6156 6 1 2 2	76 1 1 1 7 2	003003	000003	0 0 0 0
155017	1 1 1 7	1830 8 0	6106 6 1 2	6 1 1 1 6 1	3-333333	3-333333	0 0 0 0
155070	2 6 23	3856 8 2	6710 6 1 7 1 7	11 1 1 1 7 2	003003	003003	0 0 0 0
155064	16 6 6	371 8 2	6112 6 6 7 6	10 1 1 1 7 2	333333	300333	0 0 0 0
155011	28 5 12	3638 8 0	2436 6 3 3 2 2	176 1 1 1 6 2	303333	322323	0 0 0 0
155068	8 5 0	0100 8 0	6230 6 5 0 2 3	603 1 1 1 3 2	333333	303333	0 0 0 0
155027	11 1 1 15	1372 8 2	9010 6 5 5 8	76 1 1 1 7 2	003333	003000	0 0 0 0
155025	21 7 16	5000 8 0	7700 6 5 3 1 7	57 1 1 1 5 1	333333	300333	0 0 0 0
155066	24 7 16	9300 8 2	6511 6 1 2 0 1	837 1 1 1 7 2	303333	070005	0 0 0 0
155058	20 12 18	1371 8 3	4806 6 1 2	7 1 1 1 7 2	303333	303233	0 0 0 0
155038	18 8 18	1766 8 0	6619 6 7 1	3 1 1 1 7 1	003333	300000	0 0 0 0
155023	11 9 25	3408 8 2	7637 6 6 3	17 1 1 1 3 2	303333	003333	0 0 0 0

2 8	2 8	1 0 0 0 0 0	1 0 0 0 0
3 8	3 8	0 0 0 0 0	0 0 0 0 0
4 8	4 8	0 0 0 0 0	0 0 0 0 0
5 8	5 8	0 0 0 0 0	0 0 0 0 0
6 8	6 8	0 0 0 0 0	0 0 0 0 0
7 8	7 8	0 0 0 0 0	0 0 0 0 0
8 8	8 8	0 0 0 0 0	0 0 0 0 0
9 8	9 8	0 0 0 0 0	0 0 0 0 0
10 8	10 8	0 0 0 0 0	0 0 0 0 0
11 8	11 8	0 0 0 0 0	0 0 0 0 0
12 8	12 8	0 0 0 0 0	0 0 0 0 0
13 8	13 8	0 0 0 0 0	0 0 0 0 0
14 8	14 8	0 0 0 0 0	0 0 0 0 0
15 8	15 8	0 0 0 0 0	0 0 0 0 0
16 8	16 8	0 0 0 0 0	0 0 0 0 0
17 8	17 8	0 0 0 0 0	0 0 0 0 0
18 8	18 8	0 0 0 0 0	0 0 0 0 0
19 8	19 8	0 0 0 0 0	0 0 0 0 0
20 8	20 8	0 0 0 0 0	0 0 0 0 0
21 8	21 8	0 0 0 0 0	0 0 0 0 0
22 8	22 8	0 0 0 0 0	0 0 0 0 0
23 8	23 8	0 0 0 0 0	0 0 0 0 0
24 8	24 8	0 0 0 0 0	0 0 0 0 0
25 8	25 8	0 0 0 0 0	0 0 0 0 0
26 8	26 8	0 0 0 0 0	0 0 0 0 0
27 8	27 8	0 0 0 0 0	0 0 0 0 0
28 8	28 8	0 0 0 0 0	0 0 0 0 0
29 8	29 8	0 0 0 0 0	0 0 0 0 0
30 8	30 8	0 0 0 0 0	0 0 0 0 0
31 8	31 8	0 0 0 0 0	0 0 0 0 0
32 8	32 8	0 0 0 0 0	0 0 0 0 0
33 8	33 8	0 0 0 0 0	0 0 0 0 0
34 8	34 8	0 0 0 0 0	0 0 0 0 0
35 8	35 8	0 0 0 0 0	0 0 0 0 0
36 8	36 8	0 0 0 0 0	0 0 0 0 0
37 8	37 8	0 0 0 0 0	0 0 0 0 0
38 8	38 8	0 0 0 0 0	0 0 0 0 0
39 8	39 8	0 0 0 0 0	0 0 0 0 0
40 8	40 8	0 0 0 0 0	0 0 0 0 0
41 8	41 8	0 0 0 0 0	0 0 0 0 0
42 8	42 8	0 0 0 0 0	0 0 0 0 0
43 8	43 8	0 0 0 0 0	0 0 0 0 0
44 8	44 8	0 0 0 0 0	0 0 0 0 0
45 8	45 8	0 0 0 0 0	0 0 0 0 0
46 8	46 8	0 0 0 0 0	0 0 0 0 0
47 8	47 8	0 0 0 0 0	0 0 0 0 0
48 8	48 8	0 0 0 0 0	0 0 0 0 0
49 8	49 8	0 0 0 0 0	0 0 0 0 0
50 8	50 8	0 0 0 0 0	0 0 0 0 0
51 8	51 8	0 0 0 0 0	0 0 0 0 0
52 8	52 8	0 0 0 0 0	0 0 0 0 0
53 8	53 8	0 0 0 0 0	0 0 0 0 0
54 8	54 8	0 0 0 0 0	0 0 0 0 0
55 8	55 8	0 0 0 0 0	0 0 0 0 0
56 8	56 8	0 0 0 0 0	0 0 0 0 0
57 8	57 8	0 0 0 0 0	0 0 0 0 0
58 8	58 8	0 0 0 0 0	0 0 0 0 0
59 8	59 8	0 0 0 0 0	0 0 0 0 0
60 8	60 8	0 0 0 0 0	0 0 0 0 0
61 8	61 8	0 0 0 0 0	0 0 0 0 0
62 8	62 8	0 0 0 0 0	0 0 0 0 0
63 8	63 8	0 0 0 0 0	0 0 0 0 0
64 8	64 8	0 0 0 0 0	0 0 0 0 0
65 8	65 8	0 0 0 0 0	0 0 0 0 0
66 8	66 8	0 0 0 0 0	0 0 0 0 0
67 8	67 8	0 0 0 0 0	0 0 0 0 0
68 8	68 8	0 0 0 0 0	0 0 0 0 0
69 8	69 8	0 0 0 0 0	0 0 0 0 0
70 8	70 8	0 0 0 0 0	0 0 0 0 0
71 8	71 8	0 0 0 0 0	0 0 0 0 0
72 8	72 8	0 0 0 0 0	0 0 0 0 0
73 8	73 8	0 0 0 0 0	0 0 0 0 0
74 8	74 8	0 0 0 0 0	0 0 0 0 0
75 8	75 8	0 0 0 0 0	0 0 0 0 0
76 8	76 8	0 0 0 0 0	0 0 0 0 0
77 8	77 8	0 0 0 0 0	0 0 0 0 0
78 8	78 8	0 0 0 0 0	0 0 0 0 0
79 8	79 8	0 0 0 0 0	0 0 0 0 0
80 8	80 8	0 0 0 0 0	0 0 0 0 0
81 8	81 8	0 0 0 0 0	0 0 0 0 0
82 8	82 8	0 0 0 0 0	0 0 0 0 0
83 8	83 8	0 0 0 0 0	0 0 0 0 0
84 8	84 8	0 0 0 0 0	0 0 0 0 0
85 8	85 8	0 0 0 0 0	0 0 0 0 0
86 8	86 8	0 0 0 0 0	0 0 0 0 0
87 8	87 8	0 0 0 0 0	0 0 0 0 0
88 8	88 8	0 0 0 0 0	0 0 0 0 0
89 8	89 8	0 0 0 0 0	0 0 0 0 0
90 8	90 8	0 0 0 0 0	0 0 0 0 0
91 8	91 8	0 0 0 0 0	0 0 0 0 0
92 8	92 8	0 0 0 0 0	0 0 0 0 0
93 8	93 8	0 0 0 0 0	0 0 0 0 0
94 8	94 8	0 0 0 0 0	0 0 0 0 0
95 8	95 8	0 0 0 0 0	0 0 0 0 0
96 8	96 8	0 0 0 0 0	0 0 0 0 0
97 8	97 8	0 0 0 0 0	0 0 0 0 0
98 8	98 8	0 0 0 0 0	0 0 0 0 0
99 8	99 8	0 0 0 0 0	0 0 0 0 0
100 8	100 8	0 0 0 0 0	0 0 0 0 0

100 5019	0	8 5019	21 2	31 850052
100 5020	0	8 5020	21 2	850052
100 5021	0	8 5021	21 2	850052
100 5022	0	8 5022	21 2	850052
100 5023	0	8 5023	21 2	850052
100 5024	0	8 5024	21 2	850052
100 5025	0	8 5025	21 2	850052
100 5026	0	8 5026	21 2	850052
100 5027	0	8 5027	21 2	850052
100 5028	0	8 5028	21 2	850052
100 5029	0	8 5029	21 2	850052
100 5030	0	8 5030	21 2	850052
100 5031	0	8 5031	21 2	850052
100 5032	0	8 5032	21 2	850052
100 5033	0	8 5033	21 2	850052
100 5034	0	8 5034	21 2	850052
100 5035	0	8 5035	21 2	850052
100 5036	0	8 5036	21 2	850052
100 5037	0	8 5037	21 2	850052
100 5038	0	8 5038	21 2	850052
100 5039	0	8 5039	21 2	850052
100 5040	0	8 5040	21 2	850052
100 5041	0	8 5041	21 2	850052
100 5042	0	8 5042	21 2	850052
100 5043	0	8 5043	21 2	850052
100 5044	0	8 5044	21 2	850052
100 5045	0	8 5045	21 2	850052
100 5046	0	8 5046	21 2	850052
100 5047	0	8 5047	21 2	850052
100 5048	0	8 5048	21 2	850052
100 5049	0	8 5049	21 2	850052
100 5050	0	8 5050	21 2	850052
100 5051	0	8 5051	21 2	850052
100 5052	0	8 5052	21 2	850052
100 5053	0	8 5053	21 2	850052
100 5054	0	8 5054	21 2	850052
100 5055	0	8 5055	21 2	850052
100 5056	0	8 5056	21 2	850052
100 5057	0	8 5057	21 2	850052
100 5058	0	8 5058	21 2	850052
100 5059	0	8 5059	21 2	850052
100 5060	0	8 5060	21 2	850052
100 5061	0	8 5061	21 2	850052
100 5062	0	8 5062	21 2	850052
100 5063	0	8 5063	21 2	850052
100 5064	0	8 5064	21 2	850052
100 5065	0	8 5065	21 2	850052
100 5066	0	8 5066	21 2	850052
100 5067	0	8 5067	21 2	850052
100 5068	0	8 5068	21 2	850052
100 5069	0	8 5069	21 2	850052
100 5070	0	8 5070	21 2	850052
100 5071	0	8 5071	21 2	850052
100 5072	0	8 5072	21 2	850052
100 5073	0	8 5073	21 2	850052
100 5074	0	8 5074	21 2	850052
100 5075	0	8 5075	21 2	850052
100 5076	0	8 5076	21 2	850052
100 5077	0	8 5077	21 2	850052
100 5078	0	8 5078	21 2	850052
100 5079	0	8 5079	21 2	850052
100 5080	0	8 5080	21 2	850052
100 5081	0	8 5081	21 2	850052
100 5082	0	8 5082	21 2	850052
100 5083	0	8 5083	21 2	850052
100 5084	0	8 5084	21 2	850052
100 5085	0	8 5085	21 2	850052
100 5086	0	8 5086	21 2	850052
100 5087	0	8 5087	21 2	850052
100 5088	0	8 5088	21 2	850052
100 5089	0	8 5089	21 2	850052
100 5090	0	8 5090	21 2	850052
100 5091	0	8 5091	21 2	850052
100 5092	0	8 5092	21 2	850052
100 5093	0	8 5093	21 2	850052
100 5094	0	8 5094	21 2	850052
100 5095	0	8 5095	21 2	850052
100 5096	0	8 5096	21 2	850052
100 5097	0	8 5097	21 2	850052
100 5098	0	8 5098	21 2	850052
100 5099	0	8 5099	21 2	850052
100 5100	0	8 5100	21 2	850052

[illegible]

000000	2 2 1 1 V 33	01 20 1100	0 V 0001 01 2 2 002100
000000-0	1 0 1 1 V 33	01 20 2000	1 V 0001 01 21 0 002100
000000	2 0 1 1 V	01 20 2010	0 V 0121 01 21 000100
000000	2 0 1 1 V 00	01 20 2000	0 V 2000 1 2 0 000100
000000	2 2 1 1 V 00	01 20 2010	0 V 0100 01 2 0 000100
000000	0 2 1 1 V 01	01 20 0020	0 V 0000 01 11 11 000100
000000	1 0 1 1 V 00	01 20 0010	0 V 0000 01 2 0 000100
000000	1 0 1 1 V 1	0120 0000	0 V 0000 01 0 01 000100
000000	1 2 1 1 V	0120 0000	0 V 0000 01 0 00 000100
000000	1 0 1 1 V 02	01 20 0000	0 V 0021 01 11 01 000100
000000	1 2 1 1 V 1	0120 0020	0 V 0000 01 2 0 000100
000000	0 0 1 1 V 1	0120 0000	0 V 0000 01 01 00 000100
000000	2 0 1 1 V 1	01 20 0020	0 V 0121 01 2 0 000100
000000	0 0 1 1 V 00	01 20 0000	0 V 0000 01 2 01 000100
000000	1 2 1 1 V 00	01 20 0000	0 V 0000 01 1 00 000100
000000	1 0 1 1 V 01	01 20 0000	0 V 0021 01 1 01 000100
000000	2 0 1 1 V 0	01 20 0000	0 V 0000 01 0 0 000100
000000	2 0 1 1 V 1	01 20 0000	0 V 0011 01 2 0 000100
000000	1 0 1 1 V 01	01 20 0020	0 V 0100 01 0 00 000100
000000-0	1 0 1 1 V 2	01 20 1100	0 V 0111 01 0 00 000100
000000	1 0 1 1 V 200	01 20 0000	0 V 0001 01 1 00 000100
000000	0 2 1 1 V 00	01 0120 0000	0 V 0001 01 01 00 000100
000000	0 0 1 1 V 1	01 20 0000	0 V 0001 01 1 01 000100
000000	2 0 1 1 V 00	01 20 0000	0 V 0000 01 01 00 000100
000000	0 0 1 1 V	0100 0000	0 V 0001 01 1 20 000100

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

150078	30	0	17	2018	0	61	271	2000	61	1	73	1878	6	1	1	7	2	200000	000000	0	0	0	0
150080	24	0	00	1761	0	21	371	5207	5213	0		36	6	1	1	3	300000	000000	0	0	0	0	
150082	31	0	00	5877	0	70	812	2710	00	0	05	336	6	1	1	3	000000	000000	0	0	0	0	
384378	2	6	1	1831	0	72	531	1826	512	65		003	1	1	1	2	1	000000	000000	0	0	0	0
385112	18	0	0	0000	0	60	231	1756	00	0	00	366	3	1	1	1	1	000000	000000	0	0	0	0
385108	0	1	6	1806	0	66	231	2711	00	0	02	167	1	1	1	1	1	000000	000000	0	0	0	0
385097	3	0	17	0703	0	62	371	4002	00	0	0	100	1	1	1	7	2	000000	000000	0	0	0	0
111576	16	0	0	1703	0	72	320	4036	0011	00		36	1	1	1	2	2	000000	000000	0	0	0	0
385071	26	10	00	1350	0	60	733	2000	00	0	11	780	1	1	1	0	2	000000	000000	0	0	0	0
151603	3	0	00	1037	0	70	336	1604	1013			36	6	1	1	6	2	000000	000000	0	0	0	0
150068	10	0	10	2130	0	66	663	4036	00	0	1	3	6	1	1	7	0	000000	000000	0	0	0	0
385076	3	3	7	1610	0	67	367	2722	00	0	0	100	1	1	1	7	2	000000	000000	0	0	0	0
152403	23	0	13	0000	0	64	619	0200	0011			6	1	1	1	2	2	000000	000000	0	0	0	0
385068	3	3	1	1700	0	67	612	2000	00	1	10	207	1	1	1	3	2	000000	000000	0	0	0	0
1500736	20	0	13	2007	0	70	613	0007	00	0	0	3	6	1	1	6	2	000000	000000	0	0	0	0
1114	7	16	0710	0	67	603	0030	00	0	0	2	10	6	1	1	2	2	000000	000000	0	0	0	0
385067	0	17	0007	0	70	620	0012	0011	00			120	1	1	1	6	2	000000	000000	0	0	0	0
385108	0	2	00	0006	0	60	623	0001	0010	100		507	1	1	1	7	2	000000	000000	0	0	0	0
385072	11	13	00	1000	1	60	623	0610	00	0	10	3	6	6	1	7	2	000000	000000	0	0	0	0
000008	0	1	00	0006	0	60	620	1000	00	0	00	006	6	1	1	2	2	000000	000000	0	0	0	0
133008	00	12	13	1000	0	67	620	0200	0011	00		120	6	1	1	7	2	000000	000000	0	0	0	0
133008	00	21	00	0000	0	70	620	0000	0011	00		303	6	1	1	6	3	000000	000000	0	0	0	0
133010	16	3	10	0001	0	70	623	0000	0011	00		3	6	1	1	7	2	000000	000000	0	0	0	0
133015	0	00	00	1002	0	60	623	0000	0011	00		500	6	1	1	7	2	000000	000000	0	0	0	0
133007	00	11	10	0000	0	70	623	0000	0011	00		30	6	1	1	6	3	000000	000000	0	0	0	0

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1	1	1	1	24	14	110	5074	505	50	0	2055	50	2	14	55555
2	1	1	1	21	11	12	2149	500	52	0	1211	50	5	5	50111
3	1	1	1	21	01	0	1000	100	20	0	201	1	2	5	50111
4	1	1	1	20	50	25	5041	100	52	0	5002	1	5	50	50111
5	1	1	1	21	0	1110	0150	525	52	0	500	1	0	20	10001
6	1	1	1	1	1	1	5000	225	50	0	2241	5	5	11	21555
7	1	1	1	1	1	1	5024	225	52	0	500	2	5	11	50205
8	1	1	1	1	1	1	5025	225	52	0	200	1	11	5	21000
9	1	1	1	1	1	1	5051	225	22	0	500	25	5	51	205251
10	1	1	1	1	1	1	5052	225	22	0	500	1	1	11	10
11	1	1	1	1	1	1	5011	125	25	0	2051	50	1	50	205551
12	1	1	1	1	1	1	2021	015	22	0	101	10	2	01	25
13	1	1	1	1	1	1	1100	1100	22	0	5002	11	5	00	00000
14	1	1	1	1	1	1	5025	225	22	0	100	2	5	51	50
15	1	1	1	1	1	1	5000	100	22	0	500	5	1	5	500251
16	1	1	1	1	1	1	5052	225	22	0	500	1	1	20	205551
17	1	1	1	1	1	1	5019	050	52	0	200	01	1	10	200200
18	1	1	1	1	1	1	5005	500	50	0	500	21	5	10	10
19	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
20	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
21	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
22	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
23	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
24	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
25	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
26	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
27	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
28	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
29	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551
30	1	1	1	1	1	1	5005	500	50	0	500	11	5	10	205551

[illegible]

1 0	0	0	000000	000000	0
1 0	0	0	000000	000000	0
2 0	0	0	110100111	000000	1
0 0	0	0	000000	00001100	0
1 1	0	0	000000	000000	1
0 0	0	0	000000	000000	0
0 0	0	1 0	000000	000000	0
1 0	0	0 0	000000	000000	0
0 0	0	0 0	000000	000000	0
0 0	0	1 0	000000	000000	0
0 0	0	0 0	000000	000000	0
0 0	0	1 0	000000	000000	0
0 0	0	0	100100101	000000	0
0 0	0	0 0	000000	000000	0
0 1	0	0 0	000000	000000	1
0 0	0	0	000000	001001100	1
1 0	0	0	000000	000000	0
0 0	0	0 1	000000	000000	0
0 0	0	0 1	000000	000000	1
0 0	0	1 0	000000	000000	0
0 0	0	2 0	000000	000000	0
0 0	0	0	111111111	000000	1
0 0	1	0	111101111	000000	0
0 0	0	0 0	000000	000000	0

15332 27	8 1	2 56	A 1	5627 57 8 7	A 1 7 7 1	000000	000000	1 0 0 0 0
15333 14	0 1	0 12	A 1	2431 66 0 75	000 A 1 2 2 2	015127300	010001000	0 0 0 2 0
15334 27	7 7	5 37	A 1	2619 53 5 17	01 A 1 7 7 2	000000	000000	1 1 0 0 0
15335 13	7 13	1 22	A 0	2510 31 4 77	006 A 1 2 7 2	000000	000000	0 0 0 0 0
15336 14	0 10	1 55	A 1	2705 6115 72	035 A 1 2 7 2	000000	000000	0 0 0 0 0
15337 7	3 2	1 76	A 0	4711 6611 17	01 A 1 7 6 1	000000	000000	1 0 0 0 0
15338 7	0 73	1 11	A 0	4810 9012	A 1 7 7 2	000000	000000	0 1 0 0 0
15339 15	0 11	1 66	A 0	4715 47 6 10	01 A 1 2 7 2	000000	000000	1 1 0 0 0
15340 29	1 60	0 70	A 0	4208 47 7 8	11 A 1 3 2	000000	000000	0 0 0 0 0
15341 29	1 60	0 70	A 0	3605 53 7 12	02 A 1 2 7 1	000000	000000	1 0 0 0 0
15342 29	1 60	0 70	A 0	2710 83 0 9	112 A 1 7 7 2	000000	000000	0 0 0 0 1
15343 29	1 60	0 70	A 0	4103 611 75	01 7 1 7 1	000000	000000	1 0 0 1 1 1
15344 29	1 60	0 70	A 0	5301 611 14	133 1 1 7 1	00110000	000000	0 0 0 0 0
15345 14	6 15	1 30	A 0	5701 6611 77	016 1 1 2 5 1	000000	000000	0 0 0 0 0
15346 31	8 16	0 86	A 0	5311 6611 17	167 1 1 7 7 2	000000	000000	0 0 0 1 1
15347 3	3 9	0 57	A 0	2628 6511 77	1207 1 1 7 4 1	000000	000000	0 0 0 0 0
15348 16	7 17	1 30	A 0	5120 6511 77	1115 1 1 7 1	000000	000000	1 1 0 0 0 1
15349 17	1 17	0 50	A 0	7701 6611 84	131 1 1 7 1	000000	000000	0 0 0 0 0
15350 15	1 1	1 67	A 0	4826 6611 17	113 1 1 7 1	001100100	000000	0 0 0 0 0
15351 15	0 1	0 76	A 0	4703 6511 77	017 1 1 7 1	000000	000000	0 0 0 0 1
15352 15	1 1	1 68	A 0	5510 6611 81	035 1 1 7 1	000000	000000	0 0 0 0 0
15353 15	0 7	0 87	A 0	2328 6511 88	0405 1 1 7 1	01010000	010011011	0 0 0 0 0
15354 29	4 10	0 85	A 0	2710 6611 77	062 1 1 7 1	000000	000000	0 1 0 0 0
15355 2 1 11	0 11	0 11	A 0	7000 6611 77	053 1 1 7 2	000000	000000	1 0 0 0 0
15356 27 12 1	0 10	0 1	A 0	3711 6511 77	133 1 1 7 7	000000	000000	0 0 0 0 0

1	1	0	0	0	000000	000000	1
	0	0	0	0	110700101	000000	1
	0	1	0	0	000000	000000	1
	0	0	0	1	000000	000000	1
	1	0	0	0	000000	000000	1
1	0	0	0	0	000000	000000	1
	2	0	0	0	000000	000000	1
	1	2	0	0	000000	000000	1
	0	0	0	0	000000	000000	1
	0	0	0	1	000000	000000	2
	0	0	0	0	000000	000000	1
	0	0	0	0	100000111	000000110	1
	0	1	0	0	000000	000000	2
	0	0	0	0	010010111	010010110	1
	0	0	0	0	000000	000000101	2
	0	0	0	0	000000	000000	2
	0	0	0	1	000000	000000	1
	0	2	0	0	000000	001000101	1
	0	0	0	0	000000	000000	1
	0	0	0	0	000000	000000	1
	0	0	0	0	000000	000000	1
	1	0	0	0	100000111	000000	2
	0	2	0	0	000000	000000	1
	0	0	0	0	110110201	000000101	1
	0	0	0	0	100100101	000000	1

[illegible]

1	2	1	1	90	54	2	95	909	0.9	2	0	001	20	9	91	111952
1	2	1	1	1111	54	2	19	1191	0.9	1	0	221	90	21	12	000902
1	2	1	1	21	54	2	01	9090	0.9	9	0	0001	0	01	5	999992
1	2	1	1	10	11	2	17	9091	0.9	15	0	012	55	1	11	100992
1	2	1	1	192	5	019	9090	0.9	12	0	011	21	0	0	190292	
1	2	1	1	1	9	01	2090	0.9	00	0	0101	9	0	0	229052	
1	2	1	1	15	61	019	909	0.9	9	0	092	9	01	10	910952	
1	2	1	1	291	90	2	99	909	0.9	0	019	10	21	91	999192	
1	2	1	1	909	01	1	05	1117	0.9	2	0	010	90	01	91	020992
1	2	1	1	99	22	0	99	9092	0.9	05	0	9910	1	9	0	220192
1	2	1	1	999	11	9	05	209	0.9	09	0	9101	90	9	00	000951
1	2	1	1	1	1	2105	9099	0.9	90	0	0101	9	0	01	909951	
1	2	1	1	992	01	1	05	9091	0.9	0	0	009	10	0	00	200951
1	2	1	1	11	29	9	09	2091	0.9	0	0	0100	1	9	00	909951
1	2	1	1	992	01	119	9090	0.9	02	0	0001	21	9	0	990001	
1	2	1	1	990	11	9	09	1120	0.9	99	0	0001	0	9	01	999091
1	2	1	1	12	99	1199	1101	0.9	02	0	0011	90	0	0	900091	
1	2	1	1	095	01	0	99	0190	0.9	12	0	0000	21	11	0	120091
1	2	1	1	295	91	5	19	9090	0.9	09	0	0001	01	1	20	999091
1	2	1	1	192	11	0	09	9019	0.9	02	0	0021	91	0	01	120091
1	2	1	1	101	90	0	29	2007	0.9	99	0	0091	90	0	0	900091
1	2	1	1	999	01	0199	9092	101	0.9	0	0090	0	0	01	52	
1	2	1	1	12	01	1	05	9090	0.9	0	0	0090	21	0	01	909090
1	2	1	1	299	00	2	99	9091	0.9	0	0	1000	0	0	90	209090
1	2	1	1	10	90	0	09	2027	0.9	0	0	0001	99	9	21	999090

0	0	0	0	000000	000000
1	0	0	0	000000	000000
0	0	0	0	100100101	00001111
1	0	0	0	000000	00001120
0	0	0	0	000000	00000110
0	1	1	0	000000	000000
0	0	0	0	000000	000000
0	0	0	0	100100111	000000
0	0	1	0	110110205	000000
0	0	1	1	100100111	000000
1	0	0	0	000000	000000
0	0	0	0	100100011	000000
0	1	1	0	000000	000000
0	0	0	1	000000	000000
0	0	0	0	000000	000000
0	0	0	1	000000	000000
0	0	0	0	000000	000000
0	0	0	0	000000	000000
1	0	1	1	100100111	00000101
0	0	0	0	000000	000000
1	0	0	0	000000	000000
0	0	0	0	100100101	000000
0	0	0	0	110001001	000000
0	0	0	0	000000	000000

COHORT "B"

Reader 2

"Normals"

pp. 186 - 208

"Less-than-normals"

pp. 209 - 216

[illegible]

1	0	0	000000	000000
2	0	0	000000	000000
3	0	0	000000	000000
4	0	0	000000	000000
5	0	0	000000	000000
6	0	0	000000	000000
7	0	0	000000	000000
8	0	0	000000	000000
9	0	0	000000	000000
10	0	0	000000	000000
11	0	0	000000	000000
12	0	0	000000	000000
13	0	0	000000	000000
14	0	0	000000	000000
15	0	0	000000	000000
16	0	0	000000	000000
17	0	0	000000	000000
18	0	0	000000	000000
19	0	0	000000	000000
20	0	0	000000	000000
21	0	0	000000	000000
22	0	0	000000	000000
23	0	0	000000	000000
24	0	0	000000	000000
25	0	0	000000	000000
26	0	0	000000	000000
27	0	0	000000	000000
28	0	0	000000	000000
29	0	0	000000	000000
30	0	0	000000	000000
31	0	0	000000	000000
32	0	0	000000	000000
33	0	0	000000	000000
34	0	0	000000	000000
35	0	0	000000	000000
36	0	0	000000	000000
37	0	0	000000	000000
38	0	0	000000	000000
39	0	0	000000	000000
40	0	0	000000	000000
41	0	0	000000	000000
42	0	0	000000	000000
43	0	0	000000	000000
44	0	0	000000	000000
45	0	0	000000	000000
46	0	0	000000	000000
47	0	0	000000	000000
48	0	0	000000	000000
49	0	0	000000	000000
50	0	0	000000	000000
51	0	0	000000	000000
52	0	0	000000	000000
53	0	0	000000	000000
54	0	0	000000	000000
55	0	0	000000	000000
56	0	0	000000	000000
57	0	0	000000	000000
58	0	0	000000	000000
59	0	0	000000	000000
60	0	0	000000	000000
61	0	0	000000	000000
62	0	0	000000	000000
63	0	0	000000	000000
64	0	0	000000	000000
65	0	0	000000	000000
66	0	0	000000	000000
67	0	0	000000	000000
68	0	0	000000	000000
69	0	0	000000	000000
70	0	0	000000	000000
71	0	0	000000	000000
72	0	0	000000	000000
73	0	0	000000	000000
74	0	0	000000	000000
75	0	0	000000	000000
76	0	0	000000	000000
77	0	0	000000	000000
78	0	0	000000	000000
79	0	0	000000	000000
80	0	0	000000	000000
81	0	0	000000	000000
82	0	0	000000	000000
83	0	0	000000	000000
84	0	0	000000	000000
85	0	0	000000	000000
86	0	0	000000	000000
87	0	0	000000	000000
88	0	0	000000	000000
89	0	0	000000	000000
90	0	0	000000	000000
91	0	0	000000	000000
92	0	0	000000	000000
93	0	0	000000	000000
94	0	0	000000	000000
95	0	0	000000	000000
96	0	0	000000	000000
97	0	0	000000	000000
98	0	0	000000	000000
99	0	0	000000	000000
100	0	0	000000	000000

	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
I	0	0	0	000000	000000	2
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
I	0	0	0	000000	000000	2
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1
	0	0	0	000000	000000	1

0 0 0 0	000000	000000
0 0 0 1	000001	000001
0 0 1 0	000010	000010
0 0 1 1	000011	000011
0 1 0 0	000100	000100
0 1 0 1	000101	000101
0 1 1 0	000110	000110
0 1 1 1	000111	000111
1 0 0 0	001000	001000
1 0 0 1	001001	001001
1 0 1 0	001010	001010
1 0 1 1	001011	001011
1 1 0 0	001100	001100
1 1 0 1	001101	001101
1 1 1 0	001110	001110
1 1 1 1	001111	001111
0 0 0 0	010000	010000
0 0 0 1	010001	010001
0 0 1 0	010010	010010
0 0 1 1	010011	010011
0 1 0 0	010100	010100
0 1 0 1	010101	010101
0 1 1 0	010110	010110
0 1 1 1	010111	010111
1 0 0 0	011000	011000
1 0 0 1	011001	011001
1 0 1 0	011010	011010
1 0 1 1	011011	011011
1 1 0 0	011100	011100
1 1 0 1	011101	011101
1 1 1 0	011110	011110
1 1 1 1	011111	011111
0 0 0 0	100000	100000
0 0 0 1	100001	100001
0 0 1 0	100010	100010
0 0 1 1	100011	100011
0 1 0 0	100100	100100
0 1 0 1	100101	100101
0 1 1 0	100110	100110
0 1 1 1	100111	100111
1 0 0 0	101000	101000
1 0 0 1	101001	101001
1 0 1 0	101010	101010
1 0 1 1	101011	101011
1 1 0 0	101100	101100
1 1 0 1	101101	101101
1 1 1 0	101110	101110
1 1 1 1	101111	101111
0 0 0 0	110000	110000
0 0 0 1	110001	110001
0 0 1 0	110010	110010
0 0 1 1	110011	110011
0 1 0 0	110100	110100
0 1 0 1	110101	110101
0 1 1 0	110110	110110
0 1 1 1	110111	110111
1 0 0 0	111000	111000
1 0 0 1	111001	111001
1 0 1 0	111010	111010
1 0 1 1	111011	111011
1 1 0 0	111100	111100
1 1 0 1	111101	111101
1 1 1 0	111110	111110
1 1 1 1	111111	111111

[illegible]

[illegible]

[illegible]

[illegible]

000000	1 3 1 2 V 1 1	24 11 00 2074	0 V 00 01 21 1	01 00 00 00
000000	1 2 1 2 V 1 0	24 11 00 2110	0 V 00 01 21 1	01 00 00 00
000000	1 2 1 2 V 1 0	24 11 00 2074	0 V 20 01 01 0	00 00 00 00
000000	1 3 1 2 V 1 0	24 11 00 2000	0 V 00 01 00 2	21 10 00 01
000000	1 4 1 2 V 0	1 3 20 00 00	0 V 00 01 21 0	01 10 00 01
000000	1 3 1 2 V 011	01 00 00 00 00	0 V 00 11 0 2	0 00 00 01
000000	1 2 1 2 V 01	0 0 20 00 00	0 V 20 11 0 0	10 00 00 01
000000	2 2 1 2 V 0111	00 01 00 01 00	0 V 00 01 00 01	01 00 00 01
000000	1 0 1 2 V 00	00 00 00 00 00	0 V 00 01 00 0	00 21 00 01
000000	1 2 1 2 V 000	00 00 20 20 00	0 V 00 01 00 0	00 20 00 01
000000	2 2 1 2 V 000	00 00 20 00 01	0 V 20 01 20 0	00 00 00 01
000000	1 0 1 2 V 0	0 0 00 00 00	0 V 00 01 11 11	20 00 00 01
000000	2 0 1 2 V 0	0 0 11 00 00	0 V 00 01 01 0	01 00 00 01
000000	1 0 1 2 V 00	2 0 00 00 00	0 V 00 11 01 0	20 00 00 01
000000	1 2 1 2 V 00	0 2 00 20 00	0 V 20 01 0 0	10 00 00 01
000000	1 0 1 2 V 002	01 00 20 20 00	0 V 00 00 0 0	0 00 00 01
000000	1 0 1 2 V 010	00 00 00 01 00	0 V 00 11 00 0	01 20 00 01
000000	1 1 1 2 V 10	01 11 00 00 00	0 V 00 01 21 0	01 00 00 01
000000	1 2 1 2 V	0 0 00 00 00	0 V 00 01 11 11	21 00 00 01
000000	1 2 1 2 V 0	0 0 11 00 00	0 V 00 00 11 0	01 00 00 01
000000	1 0 1 2 V 001	0 0 20 00 00	0 V 20 11 0 2	00 21 00 01
000000-0	1 0 1 2 V 0	0 0 00 11 00	0 V 00 01 0 0	00 00 01 01
000000	1 0 1 2 V 000	0 0 20 20 00	0 V 00 01 01 0	01 00 00 01
000000	1 0 1 2 V 10	01 00 00 00 00	0 V 00 11 21 0	01 00 00 01
000000	1 0 1 2 V 0	0 0 00 00 00	0 V 00 01 01 0	0 00 00 01

1 1	1	0	11111	11111
2 2	0	0	11111	11111
3 3	0	0	11111	11111
4 4	0	0	11111	11111
5 5	0	0	11111	11111
6 6	0	0	11111	11111
7 7	0	0	11111	11111
8 8	0	0	11111	11111
9 9	0	0	11111	11111
10 10	0	0	11111	11111
11 11	0	0	11111	11111
12 12	0	0	11111	11111
13 13	0	0	11111	11111
14 14	0	0	11111	11111
15 15	0	0	11111	11111
16 16	0	0	11111	11111
17 17	0	0	11111	11111
18 18	0	0	11111	11111
19 19	0	0	11111	11111
20 20	0	0	11111	11111
21 21	0	0	11111	11111
22 22	0	0	11111	11111
23 23	0	0	11111	11111
24 24	0	0	11111	11111
25 25	0	0	11111	11111
26 26	0	0	11111	11111
27 27	0	0	11111	11111
28 28	0	0	11111	11111
29 29	0	0	11111	11111
30 30	0	0	11111	11111
31 31	0	0	11111	11111
32 32	0	0	11111	11111
33 33	0	0	11111	11111
34 34	0	0	11111	11111
35 35	0	0	11111	11111
36 36	0	0	11111	11111
37 37	0	0	11111	11111
38 38	0	0	11111	11111
39 39	0	0	11111	11111
40 40	0	0	11111	11111
41 41	0	0	11111	11111
42 42	0	0	11111	11111
43 43	0	0	11111	11111
44 44	0	0	11111	11111
45 45	0	0	11111	11111
46 46	0	0	11111	11111
47 47	0	0	11111	11111
48 48	0	0	11111	11111
49 49	0	0	11111	11111
50 50	0	0	11111	11111
51 51	0	0	11111	11111
52 52	0	0	11111	11111
53 53	0	0	11111	11111
54 54	0	0	11111	11111
55 55	0	0	11111	11111
56 56	0	0	11111	11111
57 57	0	0	11111	11111
58 58	0	0	11111	11111
59 59	0	0	11111	11111
60 60	0	0	11111	11111
61 61	0	0	11111	11111
62 62	0	0	11111	11111
63 63	0	0	11111	11111
64 64	0	0	11111	11111
65 65	0	0	11111	11111
66 66	0	0	11111	11111
67 67	0	0	11111	11111
68 68	0	0	11111	11111
69 69	0	0	11111	11111
70 70	0	0	11111	11111
71 71	0	0	11111	11111
72 72	0	0	11111	11111
73 73	0	0	11111	11111
74 74	0	0	11111	11111
75 75	0	0	11111	11111
76 76	0	0	11111	11111
77 77	0	0	11111	11111
78 78	0	0	11111	11111
79 79	0	0	11111	11111
80 80	0	0	11111	11111
81 81	0	0	11111	11111
82 82	0	0	11111	11111
83 83	0	0	11111	11111
84 84	0	0	11111	11111
85 85	0	0	11111	11111
86 86	0	0	11111	11111
87 87	0	0	11111	11111
88 88	0	0	11111	11111
89 89	0	0	11111	11111
90 90	0	0	11111	11111
91 91	0	0	11111	11111
92 92	0	0	11111	11111
93 93	0	0	11111	11111
94 94	0	0	11111	11111
95 95	0	0	11111	11111
96 96	0	0	11111	11111
97 97	0	0	11111	11111
98 98	0	0	11111	11111
99 99	0	0	11111	11111
100 100	0	0	11111	11111

1 2 1 2 V 21	1 2 25 0000	0 V 02001 01 21 01 00152
1 2 1 2 V 09	0 1 20 0000	0 V 00101 01 21 01 00152
1 2 1 2 V 1	21 25 0000	0 V 00011 01 21 01 00152
1 2 1 2 V 201	01 1 20 2000	0 V 10111 01 11 01 00002
2 0 1 2 V 00	02 1 25 0000	0 V 01111 01 1 01 00002
1 2 1 2 V 1	2 25 00 0000	0 V 2100 01 0 01 00002
1 0 1 2 V 02	02 2 25 0100	0 V 20001 11 0 01 11002
1 0 1 2 V 1	1 2 20 1000	0 V 00001 21 01 01 20002
1 2 1 2 V 0	2 20 0000	0 V 12111 01 01 02 00002
1 0 1 2 V	01 0 0000	0 V 00001 11 0 00 002002
1 0 1 2 V 01	1 01 0 0000	0 V 20001 0 0 01 002002
1 2 1 2 V 000	12 1 20 0000	0 V 00111 21 1 00 002002
1 0 1 2 V 01	0 0 00 0000	0 V 01121 01 01 0 210002
1 0 1 2 V 10	0 11 0 0000	0 V 01001 21 0 11 210002
1 2 1 2 V	01 0 2000	0 V 00001 01 0 0 001002
1 2 1 2 V 01	0 0 00 0000	0 V 00201 01 0 21 002002
1 2 1 2 V 0	1 11 0 0000	0 V 01001 01 0 01 011002
1 2 1 2 V 2	2 0 00 0000	0 V 02001 01 0 01 001002
2 0 1 2 V 00	0 1 20 2000	0 V 10001 01 0 2 000002
2 2 1 2 V 00	01 11 0 2000	0 V 20001 00 01 0 000002
1 0 1 2 V 00	00 11 0 0100	0 V 00001 01 11 0 000002
1 0 1 2 V 00	00 11 0 0000	0 V 00001 01 01 01 200002
2 2 1 2 V 10	21 11 0 0000	0 V 00001 21 01 0 000002
2 0 1 2 V 00	02 11 0 0000	0 V 20001 0 0 02 200002
1 2 1 2 V 001	01 11 0 0000	0 V 01201 0 2 02 001000

[illegible]

[illegible]

1	0	0	0	000000
2	0	0	0	000000
3	0	0	0	000000
4	0	0	0	000000
5	0	0	0	000000
6	0	0	0	000000
7	0	0	0	000000
8	0	0	0	000000
9	0	0	0	000000
10	0	0	0	000000
11	0	0	0	000000
12	0	0	0	000000
13	0	0	0	000000
14	0	0	0	000000
15	0	0	0	000000
16	0	0	0	000000
17	0	0	0	000000
18	0	0	0	000000
19	0	0	0	000000
20	0	0	0	000000
21	0	0	0	000000
22	0	0	0	000000
23	0	0	0	000000
24	0	0	0	000000
25	0	0	0	000000
26	0	0	0	000000
27	0	0	0	000000
28	0	0	0	000000
29	0	0	0	000000
30	0	0	0	000000
31	0	0	0	000000
32	0	0	0	000000
33	0	0	0	000000
34	0	0	0	000000
35	0	0	0	000000
36	0	0	0	000000
37	0	0	0	000000
38	0	0	0	000000
39	0	0	0	000000
40	0	0	0	000000
41	0	0	0	000000
42	0	0	0	000000
43	0	0	0	000000
44	0	0	0	000000
45	0	0	0	000000
46	0	0	0	000000
47	0	0	0	000000
48	0	0	0	000000
49	0	0	0	000000
50	0	0	0	000000
51	0	0	0	000000
52	0	0	0	000000
53	0	0	0	000000
54	0	0	0	000000
55	0	0	0	000000
56	0	0	0	000000
57	0	0	0	000000
58	0	0	0	000000
59	0	0	0	000000
60	0	0	0	000000
61	0	0	0	000000
62	0	0	0	000000
63	0	0	0	000000
64	0	0	0	000000
65	0	0	0	000000
66	0	0	0	000000
67	0	0	0	000000
68	0	0	0	000000
69	0	0	0	000000
70	0	0	0	000000
71	0	0	0	000000
72	0	0	0	000000
73	0	0	0	000000
74	0	0	0	000000
75	0	0	0	000000
76	0	0	0	000000
77	0	0	0	000000
78	0	0	0	000000
79	0	0	0	000000
80	0	0	0	000000
81	0	0	0	000000
82	0	0	0	000000
83	0	0	0	000000
84	0	0	0	000000
85	0	0	0	000000
86	0	0	0	000000
87	0	0	0	000000
88	0	0	0	000000
89	0	0	0	000000
90	0	0	0	000000
91	0	0	0	000000
92	0	0	0	000000
93	0	0	0	000000
94	0	0	0	000000
95	0	0	0	000000
96	0	0	0	000000
97	0	0	0	000000
98	0	0	0	000000
99	0	0	0	000000
100	0	0	0	000000

301567	27	7	10	11	17	0	7405	6611	14	59	1	2	1	7	1	000000
301567	10	9	19	1	06	07	6102	6611	15	28	1	2	1	9	1	000000
301566	27	6	17	14	76	0	2712	6611	13	21	1	2	1	2	1	000000
301617	29	6	9	1	00	00	2602	6611	47	10	1	2	1	2	1	000000
301626	22	11	37	1	00	00	1203	6611	53	45	1	2	1	2	1	000000
301719	12	6	17	1	26	40	2507	6611	71	126	1	2	1	2	1	000000
301765	8	1	4	1	2	50	2509	6611	73	261	1	2	1	2	1	000000
301840	14	9	11	1	00	07	2020	6611	76	693	1	2	1	2	1	000000
301952	9	2	14	1	21	00	2120	6611	97	93	1	2	1	2	1	000000
301966	11	11	13	1	1	20	2607	6611	60	26	1	2	1	2	1	000000
301970	17	6	13	1	00	07	3005	6611	27	113	1	2	1	2	1	000000
301993	24	1	10	1	00	00	3701	6611	20	205	1	2	1	2	1	000000
301994	24	7	10	11	01	0	3704	6611	39	66	1	2	1	2	1	000000
301997	8	6	11	1	00	07	3736	6611	28	72	1	2	1	2	1	000000
301998	29	1	17	1	1	13	3519	6611	25	160	1	2	1	2	1	000000
302076	23	5	13	1	2	50	4023	6611	28	248	1	2	1	2	1	000000
302096	29	2	13	1	26	15	3828	6611	75	1204	1	2	1	2	1	000000
302152	13	9	17	1	00	00	3725	6611	26	575	1	2	1	2	1	000000
302160	27	13	16	1	2	00	4208	6611	27	617	1	2	1	2	1	000000
302268	16	6	15	1	01	1	4502	6611	17	137	1	2	1	2	1	000000
302293	12	12	15	1	1	27	3509	6611	27	103	1	2	1	2	1	000000
302356	18	9	17	1	0	27	2611	6611	83	73	1	2	1	2	1	000000
302356	5	12	20	1	1	79	3005	6611	26	103	1	2	1	2	1	000000
302371	33	8	1	1	1	7	4811	6611	18	8	1	2	1	2	1	000000
302397	26	1	12	1	1	70	4507	6611	21	10	1	2	1	2	1	000000

65014	5	5	10	1741	A	2	507	50	7	4	7	1	6	1	00000	00000	0	0	0	0	
35276	13	17	32	1730	A	2	602	53	3	10	7	1	4	1	00000	00000	0	0	0	0	
35367	6	7	10	1735	A	2	623	63	6	1	2	1	7	1	00000	00000	0	0	0	0	
35368	5	9	10	1736	A	0	270	48	7	57	45	1	2	1	00000	00000	0	0	0	0	
35149	3	1	7	1741	A	0	502	51	6	1	1	2	1	6	1	00000	00000	0	0	0	0
35178	1	1	3	1747	A	0	507	67	1	1	3	1	2	1	00000	00000	0	0	0	0	
35179	3	7	7	1748	A	2	630	51	3	8	7	1	2	1	00000	00000	0	0	0	0	
35111	27	9	10	1751	A	0	470	56	3	13	1	2	1	7	1	00000	00000	0	0	0	0
35269	23	13	36	1757	A	0	471	57	3	1	6	1	2	1	00000	00000	0	0	0	0	
35311	19	3	3	1758	A	0	401	6	1	3	1	2	1	7	1	00000	00000	0	0	0	0
35347	26	7	17	1758	A	0	401	6	1	7	5	1	2	1	00000	00000	0	0	0	0	
36157	26	5	5	1759	A	2	761	47	0	6	1	7	1	7	1	00000	00000	0	0	0	0
37475	16	3	14	1759	A	2	453	1	7	1	2	1	7	2	00000	00000	0	0	0	0	
36583	3	3	10	1759	A	2	401	60	7	3	3	1	2	1	00000	00000	0	0	0	0	
36567	13	5	10	1759	A	0	500	3	0	8	9	1	2	1	00000	00000	0	0	0	0	
35333	11	6	16	1759	A	0	470	57	1	12	7	1	2	1	00000	00000	0	0	0	0	
36583	25	13	5	1759	A	0	450	3	0	8	9	1	2	1	00000	00000	0	0	0	0	
36075	4	2	5	1759	A	0	270	64	6	5	4	2	1	2	1	00000	00000	0	0	0	0
36606	23	1	1	1759	A	0	760	4	7	3	7	1	2	1	00000	00000	0	0	0	0	
36671	4	1	1	1759	A	0	721	56	6	5	1	2	1	2	1	00000	00000	0	0	0	0
36633	23	5	4	1759	A	0	450	3	0	8	1	2	1	2	1	00000	00000	0	0	0	0
36711	8	13	1	1759	A	0	440	50	1	13	3	1	2	1	00000	00000	0	0	0	0	
36710	6	3	3	1759	A	0	440	50	1	13	3	1	2	1	00000	00000	0	0	0	0	
36713	13	7	1	1759	A	0	440	50	1	13	3	1	2	1	00000	00000	0	0	0	0	
36715	13	7	1	1759	A	0	440	50	1	13	3	1	2	1	00000	00000	0	0	0	0	
36716	13	7	1	1759	A	0	440	50	1	13	3	1	2	1	00000	00000	0	0	0	0	

[illegible]

[illegible]

[illegible]

[illegible]

150379	23	7	0	12549	0	76	177	2637	6611	43	577	A	2	1	2	1	333333	000000	0	0	0	0	
154353	3	12	95	12141	0	62	177	2510	-9	1	17	190	A	2	1	2	333333	333333	0	0	0	0	
250214	15	0	36	14424	0	57	177	2651	56	4	36	133	A	2	1	2	000000	000000	0	0	0	0	
327	30	11	14	12530	0	72	197	4619	-11	17	74	1	2	1	3	1	333333	320000	0	0	0	0	
152229	31	3	14	11293	0	67	199	4700	-410	14	47	A	2	1	7	1	000000	000000	0	0	0	0	
363849	6	0	3	14133	0	56	149	2405	5413	31	1395	1	2	1	9	1	000000	030000	0	0	0	0	
356898	6	12	91	12740	0	72	143	1406	50	9	23	262	1	2	1	0	1	000000	000000	0	0	0	0
152463	13	10	14	10711	0	60	201	3611	44	4	54	A	2	1	9	1	000000	333333	0	0	0	0	
30342	4	7	3	11440	0	60	240	1604	56	8	23	63	A	2	1	4	2	000000	333333	0	0	0	0
253123	17	11	37	13993	0	50	234	3705	53	1	13	60	A	2	1	0	1	333333	000000	0	0	0	0
253566	11	12	30	13432	0	42	204	1912	4313	19	235	A	2	1	9	1	000000	000000	0	0	0	0	
157495	1	3	10	14107	0	57	209	4709	53	1	9	33	A	2	1	2	1	000000	333333	0	0	0	0
264	3	2	05	11132	0	64	341	1307	43	9	24	-32	A	2	1	0	1	333333	000000	0	0	0	0
156944	30	8	13	12757	0	60	341	3764	56	7	13	432	A	2	1	7	3	000000	000000	0	0	0	0
301533	3	11	17	13397	0	66	341	3513	6411	33	741	1	2	1	2	2	333333	000000	0	0	0	0	
154513	8	5	6	11514	0	72	330	2504	42	9	17	52	A	2	1	7	1	000000	000000	0	0	0	0
159276	22	3	96	12598	0	73	240	2010	43	6	13	813	A	2	1	7	2	333333	000000	0	0	0	0
354341	4	7	14	13340	0	62	140	4407	6312	16	144	1	2	1	9	3	000000	000000	0	0	0	0	
953358	16	5	92	13946	0	64	339	4035	46	3	5	453	1	2	1	2	3	333333	000000	0	0	0	0
953153	14	12	4	12726	0	66	343	4707	6412	22	213	1	2	1	7	2	333333	000000	0	0	0	0	
354333	7	1	04	11740	0	50	246	1439	5413	44	33	1	2	1	6	2	333333	000000	0	0	0	0	
351464	24	4	10	13715	0	74	405	3705	63	0	26	743	1	2	1	7	1	333333	000000	0	0	0	0
156335	23	1	14	13043	0	64	419	2702	46	1	12	83	A	2	1	7	2	333333	000000	0	0	0	0
133466	11	1	14	11010	0	76	423	5307	6411	13	62	1	2	1	7	1	000000	000000	0	0	0	0	
403274	29	1	13	11340	0	60	423	7025	45	4	5	42	A	2	1	9	1	000000	333333	0	0	0	0

[illegible]

156940 21 1 27 9016 0 65 420 2504 42 1 20 994 A 2 1 6 4
 157117 26 6 94 12648 0 65 420 4705 5410 7 15 A 2 1 2 1
 157664 23 2 10 12072 0 67 420 3509 46 1 10 25 A 2 1 4 2
 157717 25 2 94 12250 0 61 420 2710 54 3 30 1341 A 2 1 7 2
 158740 21 5 12 13430 0 75 420 4907 40 9 A 2 1 7 1
 158786 12 10 7 12292 0 47 420 2701 4412 17 50 A 2 1 9 2
 159196 14 3 4 11126 0 60 420 2667 60 6 33 1171 A 2 1 5 1
 159226 24 5 2 12040 0 71 420 3307 43 6 9 589 A 2 1 2 2
 159258 25 11 96 12073 0 74 420 2003 6010 31 281 A 2 1 2 1
 200007 19 2 7 12500 0 71 420 2908 6611 21 25 A 2 1 3 1
 253523 6 10 96 9025 0 71 420 2406 5912 35 61 A 2 1 7 2
 255580 23 12 15 10262 0 61 420 2402 42 3 11 433 A 2 1 7 2
 257191 11 5 16 11153 0 75 420 4510 4511 A 2 1 2 1
 257255 20 10 93 12440 0 62 420 1912 5911 30 744 A 2 1 0 1
 300463 4 10 18 14011 0 73 420 4605 6011 20 39 A 2 1 2 1
 302195 6 4 14 9254 0 75 420 3409 6011 10 121 A 2 1 7 1
 350022 3 0 15 9987 0 74 420 3306 47 5 9 1200 A 2 1 7 1
 350423 0 0 94 13155 0 49 420 1506 4013 25 1063 A 2 1 0 1
 350452 3 0 99 11110 0 52 420 1412 50 6 37 443 A 2 1 7 2
 350466 30 6 35 12175 0 68 420 2805 61 4 34 130 A 2 1 2 1
 351100 6 10 11 12006 0 63 420 1611 4310 21 1501 A 2 1 7 1
 351563 0 0 4 13242 0 65 420 2131 4211 12 458 A 2 1 7 1
 355466 12 0 0 13312 0 74 420 2010 3210 1 27 A 2 1 6 1
 355699 24 5 2 12013 0 57 420 1509 57 4 37 434 A 2 1 7 1
 357450 11 0 16 11761 0 65 420 4704 40 1 1 12 A 2 1 7 1

[illegible]

150302	22	12	5	2	1262	0	59	420	3595	40	1	12	1	2	1	0	1
35275	6	5	04	12300	0	72	454	2306	61	5	14	1793	1	2	1	0	1
753531	19	12	2	12575	0	73	450	4726	64	6	13	137	1	2	1	6	1
156404	26	4	04	12037	0	71	442	1210	50	3	2	45	4	2	1	0	1
950347	25	5	14	13034	0	57	424	4710	57	2	5	11	1	2	1	7	1
50229	20	5	02	12634	0	60	423	2026	60	5	25	105	1	2	1	7	1
351254	0	0	10	13319	0	54	430	2912	54	1	25	1167	1	2	1	7	2
950271	24	12	02	12664	0	67	422	4005	41	0	23	2325	1	2	1	0	2
355696	0	0	7	12122	0	49	422	2506	45	1	22	368	1	2	1	0	1
355098	1	3	04	12892	0	75	422	2405	64	3	39	726	1	2	1	0	1
251350	8	9	00	12513	0	65	422	2403	6110	37	122	4	2	1	7	1	1
154608	15	1	34	12099	0	71	422	1905	59	4	32	704	4	2	1	7	2
154921	14	9	1	12440	0	56	422	2906	56	5	26	390	4	2	1	2	2
155667	6	9	11	12416	0	70	422	2909	38	4	8	473	4	2	1	7	1
101344	5	12	7	12041	0	71	422	2805	6611	20	634	4	2	1	0	2	2
250412	4	2	19	13477	0	57	421	4902	46	9	6	4	4	2	1	7	1
157390	21	7	23	11769	0	64	421	2702	58	2	34	102	4	2	1	7	1
753174	4	4	14	12641	0	61	420	5807	61	7	3	13	1	2	1	2	1
553121	9	5	20	11140	0	70	420	5609	59	2	1	1	2	1	4	2	2
450674	7	7	91	9995	0	51	420	1211	5112	39	29	1	2	1	3	1	1
450370	0	0	00	12932	0	64	420	2306	26	7	2	9	1	2	1	2	2
45134	15	12	91	12574	0	59	420	725	5410	52	236	1	2	1	0	2	2
358743	22	5	2	10947	0	60	420	2409	60	2	15	169	1	2	1	2	1
358432	25	1	9	11443	0	60	420	3610	60	1	22	119	1	2	1	6	2
4751	2	1	6	13475	0	50	420	2702	6011	14	475	1	2	1	6	1	1

0	0	0	0	000000
0	0	0	1	000001
0	0	0	2	000002
0	0	0	3	000003
0	0	0	4	000004
0	0	0	5	000005
0	0	0	6	000006
0	0	0	7	000007
0	0	0	8	000008
0	0	0	9	000009
0	0	1	0	000010
0	0	1	1	000011
0	0	1	2	000012
0	0	1	3	000013
0	0	1	4	000014
0	0	1	5	000015
0	0	1	6	000016
0	0	1	7	000017
0	0	1	8	000018
0	0	1	9	000019
0	0	2	0	000020
0	0	2	1	000021
0	0	2	2	000022
0	0	2	3	000023
0	0	2	4	000024
0	0	2	5	000025
0	0	2	6	000026
0	0	2	7	000027
0	0	2	8	000028
0	0	2	9	000029
0	0	3	0	000030
0	0	3	1	000031
0	0	3	2	000032
0	0	3	3	000033
0	0	3	4	000034
0	0	3	5	000035
0	0	3	6	000036
0	0	3	7	000037
0	0	3	8	000038
0	0	3	9	000039
0	0	4	0	000040
0	0	4	1	000041
0	0	4	2	000042
0	0	4	3	000043
0	0	4	4	000044
0	0	4	5	000045
0	0	4	6	000046
0	0	4	7	000047
0	0	4	8	000048
0	0	4	9	000049
0	0	5	0	000050
0	0	5	1	000051
0	0	5	2	000052
0	0	5	3	000053
0	0	5	4	000054
0	0	5	5	000055
0	0	5	6	000056
0	0	5	7	000057
0	0	5	8	000058
0	0	5	9	000059
0	0	6	0	000060
0	0	6	1	000061
0	0	6	2	000062
0	0	6	3	000063
0	0	6	4	000064
0	0	6	5	000065
0	0	6	6	000066
0	0	6	7	000067
0	0	6	8	000068
0	0	6	9	000069
0	0	7	0	000070
0	0	7	1	000071
0	0	7	2	000072
0	0	7	3	000073
0	0	7	4	000074
0	0	7	5	000075
0	0	7	6	000076
0	0	7	7	000077
0	0	7	8	000078
0	0	7	9	000079
0	0	8	0	000080
0	0	8	1	000081
0	0	8	2	000082
0	0	8	3	000083
0	0	8	4	000084
0	0	8	5	000085
0	0	8	6	000086
0	0	8	7	000087
0	0	8	8	000088
0	0	8	9	000089
0	0	9	0	000090
0	0	9	1	000091
0	0	9	2	000092
0	0	9	3	000093
0	0	9	4	000094
0	0	9	5	000095
0	0	9	6	000096
0	0	9	7	000097
0	0	9	8	000098
0	0	9	9	000099

[illegible]

[illegible]

0	1	H	0		000000	000000
0	1	L	1	0	000000	000000
0	0	0	1	F	000000	000000
0	0	0	0	H	000000	000000
0	0	0	0		00000000	000000
0	0	0	0	L	000000	000000
0	0	0	0	C	000000	000000
0	0	0	0		00000000	000000
0	0	0	1	H	000000	000000
0	0	0	1	L	000000	000000
0	0	0	0	L	000000	000000
0	0	0	1	B	000000	000000
0	1	7	0	0	000000	000000
1	0	0	1	F	000000	000000
0	0	0	0		000000	011011
0	0	0	0	L	00011011	000000
0	0	0	1	OH	000000	000000
0	1	0	0	ZH	000000	000000
1	0	0	1	7	000000	000000
0	0	1	0		000000	000000
0	0	0	1	77	000000	000000
1	0	0	0		000000	000000
1	0	0	0		000000	000000
0	1	0	0	I	000000	000000
0	0	0	0	77	000000	000000

150348	2	5	1	0	955	A	0	4909	4811	A	2	2	6	1
150378	27	4	18	1332	A	0	4306	46	5	10	4	2	2	1
150122	4	10	9	1226	A	0	4610	50	4	9	4	2	2	1
152580	18	4	5	1203	A	0	3510	47	1	11	0	2	2	1
153000	14	4	18	1243	A	0	3507	45	1	0	278	4	2	1
154517	20	0	5	1003	A	0	2209	41	5	18	274	4	2	1
156777	21	0	20	1045	A	0	4801	43	8	1	47	4	2	1
156465	1	12	0	1015	A	0	4710	5312	6	58	4	2	2	1
157295	17	3	8	1248	A	0	2603	42	1	25	884	4	2	1
159245	4	1	1	1348	A	0	1406	45	1	51	136	4	2	1
159410	24	3	3	1438	A	0	2493	4110	47	36	4	2	2	1
230126	15	7	10	1214	A	0	2603	4411	20	346	4	2	2	1
250143	25	2	11	1213	A	0	2705	42	5	45	605	4	2	1
250908	8	11	0	1223	A	0	2706	4410	21	107	4	2	2	1
261459	12	1	13	1246	A	0	3211	50	4	5	3	4	2	1
300350	17	3	5	1310	A	0	1501	4411	45	1158	1	2	2	1
300130	19	0	10	1035	A	0	3405	4411	31	768	1	2	2	1
300209	23	6	14	1114	A	0	3512	4411	30	1169	1	2	2	1
300212	14	7	12	1320	A	0	5405	4411	12	43	1	2	2	1
300226	25	2	09	1003	A	0	3508	4411	30	116	1	2	2	1
300245	30	4	14	1347	A	0	3308	4411	31	1653	1	2	2	1
300340	14	5	4	1307	A	0	4204	4411	34	275	1	2	2	1
300342	8	6	14	1274	A	0	4208	4411	24	44	1	2	2	1
300350	10	1	0	1241	A	0	3712	4411	24	62	1	2	2	1
300352	14	4	8	1344	A	0	2808	4411	31	152	1	2	2	1

0 0	0 0 0 0	000000
1 0 1 0	0 0 7	000100101
0 0	0 0 0 0	000000
0 0	0 0	000000
0 0	0 0	000000
1 0 0	0 0	000000
0 0	0 0 0 7	000000
0 0	0 0 0 0	000000
1 0 0	0 0 0 0	000000
0 1	0 0 0 0	000000
0 0 0 0	0 0	000000
0 1 0	0 0 0 0	000000
1 1 1 7	0 0 0 0	000000
1 0	1 0	110110215
1 0	0 0	000000
0 1 7	0 0	000000
0 0	0 0 0 0	000000
1 1 0	0 0 7	000000
1 0 0	0 1 7 7	000000
0 1 1	0 0 0 0	000000
0 0 0 0	0 1 0	000000
0 0	0 1 0	000000
0 0	0 1 0 0	000000
0 1 0 0	0	000000
0 1 0 0	0	000000

1	1	0	0	0	00011011	000000	1	2	2	2
1	1	0	0	0	000000	000000	1	0	2	2
	0	0	0	0	000000	000000	2	0	2	2
	1	0	0	0	000000	000000	1	2	0	2
1	0	0	0	0	000000	000100100	1	2	0	2
	0	0	0	0	000000	000000	1	2	0	2
	0	0	0	0	000000	000000	1	0	2	2
	0	1	0	0	000000	000000	2	2	0	2
	0	1	0	0	000000	000000	1	0	2	2
	0	0	0	1	000000	000000	2	2	0	2
	1	0	0	0	000000	000000	1	0	2	2
	0	0	0	0	100100100	000000	2	2	0	2
	0	0	0	0	000000	000000	1	2	0	2
	0	0	0	0	000000	000000	1	0	2	2
	0	0	0	1	000000	000000	1	2	0	2
1	0	0	0	1	00100010	000000	2	0	2	2
	0	0	0	0	100100100	000000	1	0	2	2
1	0	0	0	0	000000	000000	1	2	2	2
	0	0	0	0	000000	010010100	1	0	2	2
	0	0	0	1	000000	000000	1	2	2	2
	0	1	0	0	000000	000100100	1	0	2	2
1	1	0	0	0	000000	000000	1	2	2	2
	0	0	0	0	00010011	000000	1	0	2	2
	1	2	0	0	000000	000000	1	0	2	2
	0	0	0	0	000000	000000	1	0	2	2

750427 16	1	3	10212	A	0	2704	41	9	0	67	T	
751103 20	1	47	17073	A	0	2004	64	6	24	254	T	
751241 17	11	17	12203	A	0	7608	64	0	24	175	T	
751551	0	0	17	12450	A	0	3606	4210	10	85	T	
751836 21	12	11	10353	A	0	2807	64	9	14	149	T	
751954	0	0	14	10315	A	0	3008	4010	1	44	T	
751962	0	0	93	10749	A	0	2006	47	5	9	228	T
752051 13	2	13	17330	A	0	3793	65	1	13	455	T	
752449 19	4	34	11984	A	0	1106	67	4	53	537	T	
752629	9	10	26	12925	A	0	3511	64	7	24	520	T
752726 14	4	7	12564	A	0	2808	64	7	22	165	T	
752759 24	11	26	12645	A	0	1710	64	7	16	277	T	
752767	6	5	14	12713	A	0	4703	64	6	15	311	T
400379 10	9	23	10043	A	0	3892	64	11	27	209	T	
400554 15	3	33	12341	A	0	2209	64	11	44	20	T	
403305 10	0	14	13115	A	0	2808	64	11	10	634	T	
450445 11	7	36	12443	A	0	2001	64	3	10	167	T	
450756 10	2	15	11100	A	0	3801	6711	10		308	T	
500131	5	1	18	14319	A	0	6511	64	11	1	2	T
650677 33	7	45	9926	A	0	4704	4810	1		14	T	
700549 15	3	7	12130	A	0	5409	64	11	13	71	T	
750126 15	6	15	11132	A	0	5405	49	0	4	9	T	
21	0	13	13318	D	44	002	2005	74	7	3	254	A
155307 16	8	31	11450	D	47	002	4206	65	8	13	27	A

0 2 0 0 0 1 0 0	000000	000000	1 0
0 0 0 0	000100 101	000000	1 2
0 0 0 0	000000	000000	1 4
1 0 0 0 0 0 0	000000	000000	1 6
1 1 0 0 0 0 0	0 110111111	000000	1 8
1 0 0 0 0	0 000000	000000	1 10
0 1 1 1 0 0 0	000000	000000	1 12
1 1 0 1 1 0 0	100110010	000000	1 14
0 0 0 0 0 0 0	000000	000000	1 16
1 0 0 0 0 0	0 100100125	011011111	1 18
1 0 0 0 0 0 0	000000	000000	1 20
0 1 0 0 0	000000	000000	1 22
0 0 0 0 1 1 1	000000	000000	2 2
1 0 0 0 0 0 0	000000	000000	1 24
1 1 0 0 0 0	010110010	000000	2 4
0 1 1 0 0 0	000000	000000	1 26
0 0 0 0 0 0	000000	000000	1 28
1 1 0 0 0 0 0	000011101	000000	1 30
1 0 0 0 0	000000	000000	1 32
0 0 0 1 0	000000	000000	2 2
1 0 0 0 1 1	000000	000000	2 4
0 1 0 1 1 1	000011110	000000	1 34
1 0 0 0 0	000000	011011111	1 36
1 1 0 0 0 0	000000	000011111	1 38
1 1 0 0 0 0	000000	011011111	1 40

0 0	0	2 115	000000	000000
0 0	0	0	000000	000000
0 0	1	0 11	100010105	000000
0 1 7	0	0 211	000000	000000
1 0 0	0	0	000000	000000
1 1 0	2	11 0 7	100100121	00010011
0 0	2	0	110101011	000000
1 2 0	1	7 11	000000	000000
0 0	0	0	110101111	000000
0 0	0	1 71	000000	000000
0 0	1	0	00010111	000000
0 0	0	0 11	000000	11111120
1 0 0	0	11 117 A	000000	000000
1 0 1	0	0 0	000000	000000
0 1	0	0	000000	000000
1 0	0	1 111	000000	000000
0 0	0	0 0	000000	000000
1 1 0	0	0 0 2	000000	000000
1 0	0	0	000000	000000
0 0	0	1 11	000000	000000
1 1 2 2 0	0	0	000000	000000
0 1 0 0 0 11 0	0	0 11	010111121	000000
1 1 0	0	0	000000	000000
1 1 1 1 0 0	0	0	111111121	000000
0 1 0	0	0	000000	000000

450311 31 12 01 13761 D 69 422 2707 63 1 30 1235 1 2 2 2 1
 550298 28 6 32 10950 D 63 422 2195 62 0 41 133 1 2 2 2 1
 352825 3 0 07 13140 D 66 433 2939 4010 5 441 1 2 2 2 1
 355541 14 5 05 12151 D 66 433 1806 61 5 44 646 1 2 2 2 1
 353446 27 1 06 11274 D 67 413 1406 6311 45 4470 1 2 2 6 1
 43233 0 0 0 12266 D 63 426 2504 83 1 17 96 1 2 2 0 1
 157323 13 7 5 10393 D 67 434 2706 47 1 19 393 A 2 2 9 1
 158160 14 8 01 11260 D 66 434 1904 56 0 37 819 A 2 2 7 1
 356109 1 A 0 11139 D 66 434 1519 5511 40 797 1 2 2 3 1
 352533 20 2 0 13416 D 69 442 2002 61 7 43 602 1 2 2 7 1
 355158 11 2 10 11193 D 74 442 4605 58 0 12 124 1 2 2 7 1
 450136 4 4 07 12119 D 64 447 1005 55 6 27 187 1 2 2 0 1
 50220 0 0 04 12052 D 67 450 2012 62 4 32 304 1 2 2 7 1
 200356 4 7 13 13034 D 65 452 4207 6611 24 160 A 2 2 8 1
 153443 11 5 10 12147 D 65 451 2911 46 3 16 310 A 2 2 6 1
 154990 12 1 09 12011 D 74 517 4303 51 0 7 19 A 2 2 6 1
 402949 12 5 20 12054 D 75 523 4408 6411 21 521 1 2 2 0 1
 301476 33 5 4 13937 D 68 523 2306 6611 42 2336 1 2 2 7 1
 153901 35 1 01 12093 D 67 525 1205 67 4 45 2493 A 2 2 0 1
 300140 12 10 5 11334 D 68 525 2404 6411 49 239 1 2 2 5 1
 950011 27 3 0 10154 D 71 527 4709 49 4 1 1 2 2 6 1
 353968 33 11 05 12474 D 61 540 1303 6112 43 512 1 2 2 7 1
 352064 26 5 04 10137 D 64 541 1205 60 5 50 1499 1 2 2 2 2
 354014 1 12 05 10076 D 60 541 1204 58 0 36 8148 1 2 2 2 2
 154925 24 0 06 12458 D 67 602 2006 61 0 41 110 A 2 2 2 2 2

1	0	0	0	0	0	000000	000000
0	0	0	1	0	110110210	000000	
1	0	0	0	0	000000	000000	

355704 27 6 05 11439 0 73 722 2308 69 4 39 137 1 2 2 6 2
350273 0 0 03 12401 0 68 012 1706 13 9 1 2 2 2 2
301266 9 11 7 12705 0 76 929 2605 6611 38 62 1 2 2 2 1

COHORT "B"

Reader 3

"Normals"

pp. 218 - 236

"Less-than-normals"

pp. 237 - 248

[illegible]

[illegible]

0 0	0 0	000000	000000	1 2 1 0 V	
0 0	0 0	000000	000000	2 2 1 0 V 051	00
0 0	0 0	000000	000000	1 0 1 0 V 059	00
1 0 0	0 0	000000	000000	1 0 1 0 V 02	00
0 0	0 0	000000	000000	1 0 1 0 V 02	00
0 0	0 0	000000	000000	1 0 1 0 V 08	01
0 0	0 0	000000	000000	2 0 1 0 V 059	00
0 0	0 0	000000	000000	1 0 1 0 V 10	01
0 0	0 0	000000	000000	1 0 1 0 V 109	00
0 0	0 0	000000	000000	1 0 1 0 V 02	01
0 0	0 0	000000	000000	1 2 1 0 V 10	01
0 0	0 0	000000	000000	1 0 1 0 V 2	01
0 0	0 0	000000	000000	2 0 1 0 V 01	00
0 0	0 0	000000	000000	1 0 1 0 V 021	01
0 0	0 0	000000	000000	2 0 1 0 V 00	01
0 0	0 0	000000	000000	2 0 1 0 V 005	00
1 0 0	0 0	000000	000000	2 0 1 0 V 02	00
0 0	0 0	000000	000000	1 0 1 0 V 009	00
0 0	0 0	000000	000000	2 0 1 0 V 21	01
1 0 0	0 0	000000	000000	2 2 1 0 V 09	00
1 0 0	0 0	000000	000000	2 0 1 0 V 005	00
0 0	0 0	000000	000000	2 2 1 0 V 02	01
0 0	0 0	000000	000000	2 2 1 0 V 001	00
1 0 0	0 0	000000	000000	2 2 1 0 V 201	00
0 0	0 0	000000	000000	1 2 1 0 V 05	01

[illegible]

L	C	C	CCCCC	CCCCC
U	O	C	O	CCCCC
C	O	O	C	CCCCC
O	O	O	C	CCCCC
O	C	C	C	CCCCC
O	C	O	C	CCCCC
O	C	O	O	CCCCC
O	C	O	O	CCCCC
C	C	C	C	CCCCC
I	O	O	C	CCCCC
O	C	C	C	CCCCC
O	O	O	C	CCCCC
O	O	C	C	CCCCC
I	O	O	C	CCCCC
O	O	C	O	CCCCC
U	C	C	C	CCCCC
O	O	C	O	CCCCC
I	O	C	C	CCCCC
O	O	O	O	CCCCC
O	C	C	C	CCCCC
O	C	O	O	CCCCC
O	O	C	C	CCCCC
O	O	C	O	CCCCC
I	O	C	O	CCCCC
C	O	C	C	CCCCC

[illegible]

[illegible]

150976 18	4 10 14371 A	0
150902	9 12 11 14173 A	0
150919 11	9 11 3447 A	0
150943 12 10 14	3035 A	0
151145 26	4 17 3012 A	0
151193	2 10 13 206 A	0
151221 1	6 10 517 A	0
151288 29	9 13 3062 A	0
151315 28	5 13 41 A	0
151515 17	9 16 14200 A	0
151545 14	9 13 14232 A	0
151542 30	6 4 3223 A	0
151837 24	3 2 306 A	0
151935 15	4 18 14553 A	0
151965 10	9 17 14560 A	0
152066	3 2 9 3319 A	0
152165 12	8 14 2879 A	0
152223 24	7 34 2661 A	0
152364 21	7 16 3912 A	0
152468	4 5 11 3524 A	0
152575 30 11	9 2379 A	0
152643 25 12 14	2428 A	0
152704	1 2 13 3835 A	0
152978	5 9 23 14408 A	0
153387 19	1 19 3746 A	0
3509 45	9 10	
26	4 7 1 3	
15	4 3 1 3 2	
4	4 4 7 1 7 2	
14	4 3 1 4 1	
251	4 7 1 7 1	
2909	57 7 27	
4808	40 4 11	
4708	4713	
3703	34 7 1	
3611	44 6 7	
4807	49 7 1	
2009	44 9 27	
4305	42 8 9	
4505	4511	
3702	4611 9	
2702	47 6 20	
3707	38 2	
3611	41 2 24	
3404	50 5 16	
3506	46 3 10	
3504	34 4 2	
4305	43 4 2	
4305	42 8 9	
473	4 3 1 4 1	
473	4 3 1 4 1	
5101	4712 6	
74	4 3 1 4 1	

[illegible]

153133 13	4 11	3105 A	0	3702 30 1	58 A 3 1 7 1
153105 22	3 9	2647 A	0	4710 03 1	5 A 7 1 2 1
153175 24	8 16	2014 A	0	3405 51 0	123 A 7 1 2 1
153076 11	7 20	3044 A	0	4610 51 6	77 A 7 1 7 1
153067 10	1 18	2064 A	0	4702 0012 1	19 A 3 1 7 1
153077 25	3 18	3631 A	0	4711 5011 3	6 A 3 1 0 1
153003 26	1 10	14270 A	0	3608 40 2	121 A 3 1 7 1
153088 27	5 12	3066 A	0	4009 40 9	18 A 3 1 0 1
153068 2 12	10	1668 A	0	3905 03 0 10	156 A 3 1 7 1
153060 24	2 16	3123 A	0	4204 46 2 1	10 A 7 1 7 1
153093 26 10	5	127 A	0	3701 5011 20	451 A 7 1 7 1
153220 11 10	7	4127 A	0	2908 42 1 12	406 A 7 1 8 1
153108 4	1 16	2017 A	0	3510 46 7	45 A 3 1 7 1
153051 25	1 17	4109 A	0	4902 50 7 2	18 A 3 1 2 1
153170 14	5 13	4407 A	0	4710 49 6 1	12 A 7 1 7 1
153021 15	5 17	3107 A	0	5007 51 5	1 A 7 1 0 1
153027 25 11	15	14315 A	0	4110 41 6 1	4 A 7 1 7 1
153030 9 12 18	14	14657 A	0	3611 47 2 10	154 A 7 1 8 1
153054 24 10 13	3	4642 A	0	3502 47 5 10	37 A 3 1 0 1
153060 12	7 10	2606 A	0	5105 01 7	A 7 1 6 1
153162 15	7 12	1012 A	0	4704 40 9 1	1 A 3 1 6 1
153036 2	8 16	2720 A	0	4610 47 5	1 A 7 1 7 1
153050 25	8	1453 A	0	4808 45 2 16	10 A 4 1 2 2
153072 17	9 12	25 A	0	4007 5012 10	20 A 7 1 4 2
153051 21	3 15	2757 A	0	4011 4611 6	18 A 3 1 2 1

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

250721 10	4 20	7 A	0	4501 45 9	2 A 3 1
250750 19	7 20	3747 A	0	4310 47 7	21 A 3 1
25076 9	9 9	14261 A	0	7603 47 4 10	6 A 3 1
250449 20	6 30	14571 A	0	3609 46 9 10	242 A 3 1
250619 24	12 16	39 A	0	4301 43 9	1 A 3 1
250719 11	4 19	2692 A	0	4303 43 6	1 A 3 1
250735 17	4 17	14425 A	0	4106 42 5	7 A 3 1
250800 20	6 19	56 A	0	4601 50 5 4	20 A 3 1
250919 33	12 20	3498 A	0	2707 45 4 8	4 A 3 1
250966 25	1 20	4040 A	0	3705 45 9 8	137 A 3 1
251010 14	2 13	2924 A	0	4705 47 8	A 3 1
251029 13	8 19	4074 A	0	4208 44 4 1	14 A 3 1
251105 23	4 17	512 A	0	5501 6510 11	59 A 3 1
251195 4	9 14	14471 A	0	3611 45 4 8	140 A 3 1
251261 15	10 11	3930 A	0	4209 44 6 1	12 A 3 1
251364 16	12 0	66 A	0	3705 38 4	2 A 3 1
251633 11	2 15	3645 A	0	4304 46 4 2	29 A 3 1
251724 2	1 8	2993 A	0	3410 4411 13	53 A 3 1
251789 29	2 16	3867 A	0	4106 43 1 1	17 A 3 1
251830 27	2 6	4039 A	0	4409 4411	7 A 3 1
251927 28	4 17	134 A	0	3401 33 7 5	22 A 3 1
252034 14	5 14	1203 A	0	4405 31 9 7	4 A 3 1
252961 9	2 6	1011 A	0	2605 35 9 9	54 A 3 1
253127 4	7 14	354 A	0	3707 4411 26	157 A 3 1
253317 21	6 14	2637 A	0	7405 3411 25	274 A 3 1

[illegible]

301697	13	7	19	2717	A	0	3512	6611	23	136	1	3	1	7	1
301671	10	9	10	1414	A	0	2905	6611	29	146	1	3	1	0	1
301634	21	5	20	1631	A	0	3710	6611	20	420	1	3	1	5	1
301579	11	9	15	1452	A	0	3703	6611	24	246	1	3	1	0	1
301526	15	2	14	1433	A	0	2812	6611	36	415	1	3	1	7	1
301473	9	12	9	1314	A	0	2727	6611	38	423	1	3	1	7	1
301451	22	1	14	14	A	0	5312	6611	12	109	1	3	1	6	1
301363	12	1	15	1432	A	0	3704	6611	30	620	1	3	1	7	1
301272	29	13	19	2655	A	0	3007	6611	27	242	1	3	1	0	1
301273	27	9	19	2917	A	0	4706	6611	24	189	1	3	1	7	1
301261	19	11	9	3834	A	0	2907	6611	23	241	1	3	1	7	1
301227	6	5	17	3435	A	0	4704	6611	19	40	1	3	1	7	1
301146	14	5	3	14415	A	0	2612	6611	30	770	1	3	1	1	1
301107	20	11	23	3440	A	0	4212	6611	23	244	1	3	1	7	1
300945	25	9	14	393	A	0	4505	6611	21	422	1	3	1	3	1
300919	19	11	14	3218	A	0	4509	6611	20	155	1	3	1	3	1
300843	13	5	19	349	A	0	3710	6611	29	202	1	3	1	5	1
300733	16	3	19	4939	A	0	3703	6611	25	94	1	3	1	4	1
300760	12	11	15	3274	A	0	3907	6611	27	627	1	3	1	7	1
300723	9	9	14	3420	A	0	4703	6611	28	560	1	3	1	7	1
300560	4	6	20	294	A	0	4307	6611	23	656	1	3	1	0	2
300470	6	4	15	2845	A	0	3710	6611	24	64	1	3	1	7	1
300426	2	2	14346	A	0	1709	6611	45	32	1	2	1	7	1	1
300367	22	2	14	1470	A	0	3702	6611	23	366	1	3	1	3	1
300342	5	1	12	2740	A	0	3408	6611	24	443	1	3	1	4	1

7	C	C	C	CC0000	CC0000
0	C	0	C	CC0000	CC0000
3	C	C	0	CC0000	CC0000
3	C	C	C	CC0000	CC0000
0	0	C	0	CC0000	CC0000
0	C	0	0	CC0000	CC0000
3	C	C	C	CC0000	CC0000
3	0	C	0	CC0000	CC0000
0	0	C	0	CC0000	CC0000
0	0	0	C	CC0000	CC0000
0	C	C	0	CC0000	CC0000
0	0	0	0	CC0000	CC0000
0	0	C	C	CC0000	CC0000
0	C	C	0	CC0000	CC0000
0	0	0	0	CC0000	CC0000
0	0	C	C	CC0000	CC0000
0	C	C	0	CC0000	CC0000
3	C	C	0	CC0000	CC0000
3	C	C	C	CC0000	CC0000
0	0	0	C	CC0000	CC0000
0	0	C	C	CC0000	CC0000
0	0	C	0	CC0000	CC0000
0	0	0	0	CC0000	CC0000
0	0	C	C	CC0000	CC0000
0	0	C	0	CC0000	CC0000
0	0	C	C	CC0000	CC0000
0	0	C	0	CC0000	CC0000
0	0	0	0	CC0000	CC0000

301721 19 10 19 14179 A 0	5504 6611 11	5 T 3 1 2 1
301721 29 5 10 7003 A 0	3606 6611 29	253 T 3 1 1 1
301864 10 9 7 3076 A 0	4311 6611 21	469 T 3 1 0 1
301880 6 3 16 14346 A 0	3703 6611 29	16 T 3 1 7 1
301907 16 12 7 3710 A 0	2509 6611 17	2341 T 3 1 4 1
302034 15 6 6 149 A 0	2504 6611 30	219 T 3 1 8 1
302131 23 9 4 3049 A 0	3604 6611 27	36 T 1 1 1 7 1
302132 5 9 20 7006 A 0	4001 6611 23	137 T 3 1 7 1
302179 2 3 17 14491 A 0	5501 6611 11	5 T 3 1 0 1
302202 10 11 4 3278 A 0	3609 6611 30	304 T 2 1 2 1
302240 16 2 29 14309 A 0	3611 6611 30	136 T 3 1 7 1
302296 9 9 16 14509 A 0	4207 6611 24	92 T 1 3 1 6 1
302299 18 0 1 2716 A 0	2904 6611 38	156 T 3 1 0 1
350195 14 9 7 7057 A 0	4311 66 6 23	74 T 3 1 0 1
350323 1 4 36 7901 A 0	2904 66 4 29	681 T 3 1 2 1
350677 0 0 16 3298 A 0	3607 29 9 7	8 T 3 1 7 1
350942 19 12 16 3847 A 0	3610 6611 29	254 T 3 1 7 1
351212 7 5 12 3307 A 0	4508 47 9 2	15 T 3 1 6 1
351437 0 1 12 4149 A 0	5604 59 0	1 T 3 1 2 1
351911 0 0 14 14574 A 0	3204 4411 11	134 T 3 1 9 1
351908 4 5 15 3074 A 0	3611 66 5 24	72 T 3 1 7 1
352319 24 8 23 14224 A 0	5402 66 5 13	23 T 3 1 8 1
353722 0 0 6 14429 A 0	3802 51 2 11	46 T 3 1 9 1
354772 12 5 14 14580 A 0	3510 66 6 24	954 T 3 1 7 1
354754 1 12 9 3374 A 0	2907 34 0	2 T 3 1 4 1

[illegible]

[illegible]

600720	24	6	14	744	A	0	5406	6611	12	56	1	3	1	5	2	
600648	14	1	12	2457	A	0	4639	6611	20	217	1	3	1	0	1	
600117	17	6	30	4763	A	0	4513	6611	21	314	1	3	1	7	1	
650702	6	5	19	4435	A	0	4602	47	5	2	1	3	1	7	1	
650200	10	4	10	3444	A	0	4701	47	1	1	7	1	0	1		
653333	31	5	30	14127	A	0	4609	4610								
650464	5	6	19	14201	A	0	4610	4611								
650574	27	11	30	4143	A	0	4607	4610								
650571	29	2	14	14612	A	0	4605	47	5	35	1	3	1	0	1	
703163	31	8	19	153	A	0	5704	6611	9	19	1	3	1	0	1	
750000	15	6	19	1605	A	0	5602	62	6	6	3	1	3	1	9	2
750280	26	7	30	14518	A	0	5411	5412								
750234	31	5	17	4544	A	0	5409	55	1	1	3	1	7	1		
903055	21	1	19	1741	A	0	4704	6611	13	157	1	3	1	7	1	
900045	3	11	19	14375	A	9	6303	5611	3	49	1	3	1	7	1	
900027	29	13	1	14371	A	0	4002	6611	24	533	1	3	1	2	2	
900119	25	13	15	2736	A	0	4005	6611	21	537	1	3	1	5	1	
154397	23	5	13	2498	D	72	4604	4611								
153705	5	3	1	4199	D	67	2508	52	9	15	75	4	3	1	7	1
251597	2	4	1	14435	D	55	3611	37	9							
155390	24	9	12	4332	D	55	3007	2905	53	7	495	4	3	1	3	1
450397	24	3	5	14129	D	67	352	2305	47	1	32	357	1	3	1	2
754521	18	1	19	14139	D	67	013	4501	6111	16	141	1	3	1	7	1
50043	22	11	4	14379	D	75	151	2307	53	1	7	73	1	3	1	6
80146	0	2	12	14146	D	64	151	2805	49	7	17	570	1	3	1	6

[illegible]

150057 31 7 10 10078 0 65 151 0608 5710 1 2 A 7 1 6 1
 155730 6 8 12 0 71 0 60 151 2007 07 9 23 1 000 A 3 1 7 3
 40131 0 0 0 0056 0 60 153 2009 03 9 7 00 1 3 1 6 1
 157001 9 5 90 76 0 60 153 2005 04 11 15 00 A 7 1 5 1
 750216 6 6 0 7125 0 71 157 0010 5011 0 10 1 7 1 0 1
 150031 7 0 1 1003 0 65 150 0500 0010 10 00 A 4 1 0 2
 150036 2 1 10 0035 0 69 150 0005 0011 13 A 3 1 0 1
 151733 3 4 0 0119 0 67 157 2010 00 7 12 37 A 3 1 7 1
 251538 26 1 20 0006 0 72 157 3602 0012 0 10 A 3 1 0 1
 150047 10 3 10 0022 0 71 150 0302 00 9 5 16 A 7 1 7 1
 45 20 5 50 2003 0 67 162 2003 0011 36 650 A 3 1 0 1
 10150 20 0 8 0151 0 71 160 2306 0011 00 000 T 3 1 7 3
 50707 0 0 7 2707 0 70 160 2903 00 6 10 307 T 3 1 6 1
 150002 20 11 13 0006 0 65 160 5007 00 7 0 20 A 7 1 0 1
 151002 22 3 9 0001 0 60 162 3509 00 8 10 070 A 7 1 0 2
 250002 4 11 06 1003 0 60 160 0703 00 8 5 00 A 7 1 0 1
 150709 25 10 7 0000 0 72 162 0000 00 1 10 100 T 7 1 0 1
 050011 21 4 10 0000 0 60 162 5003 0012 0 07 1 7 1 7 1
 157062 9 11 0 0100 0 67 163 2700 00 7 20 001 A 7 1 7 1
 350030 10 0 01 0000 0 72 177 3012 00 2 01 100 T 7 1 0 1
 150106 0 0 35 0000 0 50 177 1012 00 7 1 10 1 7 1 7 2
 00200 16 0 0 0700 0 60 181 1500 00 0 11 100 T 7 1 7 1
 151601 0 0 01 0000 0 67 190 1005 00 7 20 000 T 7 1 0 1
 250041 30 5 0 10000 0 60 190 0200 00 5 7 A 7 1 0 1
 150070 3 10 10 10070 0 60 197 5000 00 0 2 1 A 7 1 7 1

[illegible]

101670 70 10 0 0746 D 74 200 7003 6011 20
 159475 50 12 12 36 D 68 200 3602 74 6 2
 153460 3 11 00 4034 D 67 204 2402 4012 76
 450310 11 12 12 153 D 66 204 3710 58 0 23
 158454 6 6 7 14174 D 64 260 4005 4012
 353420 0 0 05 2650 D 46 222 2803 4011 18
 155283 19 12 15 295 D 60 310 3302 60 7 27
 10190 22 4 18 14188 D 72 341 3906 6011 26
 250540 24 5 19 4032 D 63 331 5005 5012 5
 11 A 3 1 6 1
 699 1 3 1 6 2
 732 A 3 1 9 2
 321 1 3 1 3 1
 8 A 3 1 0 1
 450310 11 12 12 153 D 66 204 3710 58 0 23
 158454 6 6 7 14174 D 64 260 4005 4012
 353420 0 0 05 2650 D 46 222 2803 4011 18
 155283 19 12 15 295 D 60 310 3302 60 7 27
 10190 22 4 18 14188 D 72 341 3906 6011 26
 250540 24 5 19 4032 D 63 331 5005 5012 5
 11 A 3 1 6 1
 699 1 3 1 6 2
 732 A 3 1 9 2
 321 1 3 1 3 1
 8 A 3 1 0 1
 450310 11 12 12 153 D 66 204 3710 58 0 23
 158454 6 6 7 14174 D 64 260 4005 4012
 353420 0 0 05 2650 D 46 222 2803 4011 18
 155283 19 12 15 295 D 60 310 3302 60 7 27
 10190 22 4 18 14188 D 72 341 3906 6011 26
 250540 24 5 19 4032 D 63 332 1904 4010 21
 158032 4 5 05 1022 D 56 332 1904 4010 21
 155790 20 9 8 341 D 42 732 3411 42 4 7
 155708 2 10 10 14486 D 70 332 4705 60 4 20
 102 23 4 12 60 D 66 332 3703 48 2 10
 353456 10 10 07 14349 D 65 331 2509 6011 16
 352807 24 5 7 3646 D 64 331 3607 6010 22
 352704 1 8 01 374 D 74 331 2206 58 0 36
 1701 1 3 1 2 2
 370 1 3 1 0 2
 506 A 3 1 4 2
 5 A 3 1 9 1
 739 A 3 1 7 1
 197 A 3 1 2 1
 149 A 3 1 2 1
 196 A 3 1 4 1
 36 T 3 1 7 1
 191017 4 12 17 1456 D 73 414 3408 4011 24
 251675 5 4 15 3646 D 64 416 3705 5011 2
 107 3 11 19 170 D 65 423 3909 47 4 7
 205 21 8 17 14387 D 68 423 3411 50 4 31
 10534 22 2 18 2730 D 67 420 4508 6011 19
 449 T 3 1 7 1

	O	C	E	C	OCCCEC	CCCCC
	O	C	O	E	CCCCEO	CCCCC
	O	C	C	C	CCCCCO	CCCCC
	C	O	O	O	OCOCOC	CCCCC
	O	O	C	C	OCOCOC	CCCCC
	C	C	C	E	CCCCCO	CCCCC
	O	C	C	C	CCCCCO	CCCCC
	C	E	O	E	CCCCCO	CCCCC
	O	E	E	O	CCCCCO	CCCCC
I	O	C	C	O	CCCCCO	CCCCC
	C	O	O	E	CCCCCO	CCCCC
I	O	C	C	O	CCCCCO	CCCCC
	O	E	C	O	CCCCCO	CCCCC
I	O	C	C	O	CCCCCO	CCCCC
	O	C	C	O	CCCCCO	CCCCC
	O	E	O	E	CCCCCO	CCCCC
I	O	C	C	C	CCCCCO	CCCCC
	O	C	O	O	CCCCCO	CCCCC
	E	O	O	O	CCCCCO	CCCCC
	O	O	O	O	CCCCCO	CCCCC
	O	C	C	O	CCCCCO-C	CCCCC
	O	C	O	O	CCCCCO	CCCCC
I	C	O	C	O	CCCCCO	CCCCC
	O	C	C	C	CCCCCO	CCCCC

40363 24 0 00 14448 0 47 420 2111 47 8 5
 50144 14 1 8 14509 0 65 420 2611 5612 11
 50523 0 0 06 2617 0 46 420 2001 4712 16
 50630 20 10 11 14219 0 57 420 3501 4613 3
 50365 0 0 1 14393 0 57 420 2012 56 4 2
 51074 0 0 0 14140 0 63 420 1904 6311 0
 40275 0 0 2 4664 0 59 420 2907 53 4 11
 40277 1 1 4 3485 0 66 420 2564 6011 45
 80292 1 7 08 4100 0 64 420 2305 59 3 11
 100025 15 1 4 2577 0 74 420 2404 61 37
 100596 15 6 15 2753 0 72 420 3030 61 37
 100617 1 1 20 4521 0 73 420 4704 6011 12
 101256 17 3 15 7034 0 77 420 4404 61 18
 101549 2 6 15 2917 0 65 420 3704 6011 24
 101595 11 5 18 14160 0 67 420 4136 5611 26
 150014 22 6 10 2927 0 61 420 3210 43 0 2
 150373 1 9 6 1310 0 74 420 2910 43 7 1
 151657 4 6 11 4721 0 72 420 3710 43 3 3
 152387 6 11 17 4344 0 72 420 4503 43 5 1
 152527 21 6 4 14427 0 64 420 7011 1 1
 154061 20 0 14 2980 0 67 420 5207 39 6 11
 154254 30 1 8 2741 0 67 420 5612 43 0 7
 155039 2 7 23 3444 0 65 420 4704 73 8 11
 155474 1 12 11 1327 0 71 420 4807 5113 3
 155917 12 7 20 4530 0 64 420 3710 35 4

[illegible]

156944 13 7 2 3576 D 75 420 2511 4512 10
 157195 2 7 5 754 D 68 420 4301 40 5 6
 157493 16 4 8 14705 D 67 420 2902 45 5 16
 159376 19 4 47 2764 D 69 420 2203 62 4 40
 154272 5 4 0 2942 D 61 420 3701 37 4
 154413 23 4 25 2938 D 72 420 4412 45 1 4
 159435 19 4 10 513 D 66 420 4503 612 19
 159468 12 11 7 4033 D 62 420 4711 61 3 12
 250026 31 10 18 2643 D 64 420 4704 48 4 1
 250124 29 3 0 4903 D 52 420 4106 5212 11
 250250 14 4 12 4173 D 63 420 4204 5311 9
 251166 41 4 17 14524 D 64 420 4703 4711
 300429 4 4 10 116 D 65 420 4505 6611 20
 300527 7 10 18 3295 D 70 420 3902 6611 27
 301574 15 4 12 2710 D 76 420 2906 6611 25
 352583 0 0 27 2900 D 68 420 2004 4211 22
 356433 24 1 36 3947 D 58 420 15027 5711 40
 358726 19 4 3 2624 D 65 420 4205 66 4 21
 100044 2 3 14 136 D 60 444 4610 6611 20
 155749 10 10 12 3307 D 46 444 2509 66 4 10
 155908 2 5 25 14368 D 55 444 1309 6612 42
 152193 2 5 4 450 D 65 465 2004 4712 27
 150271 14 1 2 4152 D 44 499 4103 4712 2

[illegible]

50020 16 11 10 6000 D 50 401 5006 50 3 1
 050004 5 0 06 17 0 77 901 5001 50 2 6
 101715 11 11 16 3856 D 67 502 3010 6011 32
 152412 17 6 13 3203 D 63 502 4005 61 3 11
 100569 14 9 13 2709 D 66 527 4712 6011 19
 156260 24 9 18 3606 D 44 527 3503 4010 7
 351952 22 3 1 2011 D 76 527 2506 60 7 30
 154623 18 2 02 10017 D 43 504 2513 4711 18
 156987 29 9 14 3862 D 40 550 4200 45 7 2
 159259 19 1 12 2976 D 67 570 4301 57 2 12
 40186 3 0 05 3300 D 60 581 2101 40 6 27
 153653 3 6 14 274 D 61 581 4801 50 3 1
 50507 0 0 3 1000 D 60 590 1704 40 3 22
 157814 22 2 04 2010 D 53 590 1808 40 1 30
 155418 8 3 12 3006 D 75 501 5001 5011 8
 200730 10 4 14 320 D 60 502 3510 6011 33
 159309 4 3 03 10154 D 73 603 4309 40 4 2
 159008 14 12 16 3869 D 60 757 4209 45 9 3
 358328 3 0 17 10159 D 61 757 4008 40 3 5
 50792 25 1 17 247 D 48 812 4605 48 6 2
 100135 14 7 2 240 D 71 812 4106 4611 25
 154420 21 5 0 1167 D 58 812 2803 31 2 2
 155656 13 2 11 2407 D 63 812 4723 47 5
 400330 1 1 11 2011 D 67 816 4301 6011 16
 153083 26 11 2 10107 D 50 816 2200 47 2 4
 170 4 3 1 7 1
 151 3 1 7 1
 152 3 1 7 1
 153 3 1 7 1
 154 3 1 7 1
 155 3 1 7 1
 156 3 1 7 1
 157 3 1 7 1
 158 3 1 7 1
 159 3 1 7 1
 160 3 1 7 1
 161 3 1 7 1
 162 3 1 7 1
 163 3 1 7 1
 164 3 1 7 1
 165 3 1 7 1
 166 3 1 7 1
 167 3 1 7 1
 168 3 1 7 1
 169 3 1 7 1
 170 3 1 7 1
 171 3 1 7 1
 172 3 1 7 1
 173 3 1 7 1
 174 3 1 7 1
 175 3 1 7 1
 176 3 1 7 1
 177 3 1 7 1
 178 3 1 7 1
 179 3 1 7 1
 180 3 1 7 1
 181 3 1 7 1
 182 3 1 7 1
 183 3 1 7 1
 184 3 1 7 1
 185 3 1 7 1
 186 3 1 7 1
 187 3 1 7 1
 188 3 1 7 1
 189 3 1 7 1
 190 3 1 7 1
 191 3 1 7 1
 192 3 1 7 1
 193 3 1 7 1
 194 3 1 7 1
 195 3 1 7 1
 196 3 1 7 1
 197 3 1 7 1
 198 3 1 7 1
 199 3 1 7 1
 200 3 1 7 1

[illegible]

0 0	0 0	11011111 000000
0 0	0 0 1	11110011 000000
0 0	0 0	000000 000000
0 1 00	0 0	000000 000000
0 0	0 0	11011001 000000
1 0	0 1 7	10010011 000000
0 0	0 0	10010010 000000
0 0	0 0	10010010 000000
1 1 0	0 0	11111100 000000
1 0	0 0	10010011 000000
0 0	0 7 0	10010010 000000
0 2 00	0 0	10010010 000000
0 0	0 0	10010011 000000
1 0 0	0 0	11011010 000000
0 1 7 0	0 0	000000 000000
0 0	0 0	11011011 000000
0 1 1 0	0 0	10010011 000000
0 0	0 17	000000 000000
0 0	0 0	11011011 000000
0 0	0 0	10010011 000000
0 0	0 0	11011011 000000
0 0	0 0	000000 000000
0 0	0 0	11011011 000000
1 0	0 0	11011011 000000
1 0 0	0 0	10010011 000000

100 11 1 0 1507 A 0	2305 6610 40	440 A 3 2 2 2
217 0 0 06 142 A 0	2004 6611 37	04 T 3 2 6 1
10019 5 8 07 2956 A 0	4508 6611 16	56 T 3 2 7 1
10346 24 10 16 4074 A 3	3710 6611 05	117 T 3 2 7 1
10122 6 4 17 3731 A 0	3709 6611 21	43 T 3 2 4 1
10146 18 7 14 3693 A 0	3606 6611 27	241 T 3 2 7 1
10460 10 6 19 3139 A 0	4509 6611 19	130 T 3 2 7 1
10455 30 6 23 4053 A 0	5503 6611 11	47 T 3 2 4 1
50169 13 10 06 351 A 0	2005 66 9 20	332 T 3 2 2 2
50429 0 0 09 3149 A 0	2604 5111 7	300 T 3 2 7 1
50730 4 8 16 14125 A 0	3101 66 6 21	290 T 3 2 7 1
40002 2 5 7 3445 A 0	1905 6611 23	241 A 3 2 8 2
40026 0 0 13 112 A 0	2503 6611 21	663 T 3 2 2 1
40054 0 0 4 4472 A 0	2207 6611 30	123 T 3 2 7 1
40055 0 0 19 255 A 0	2809 6611 34	1100 T 3 2 4 1
40087 0 0 19 2955 A 0	3704 6611 29	245 T 3 2 7 1
40131 10 10 11 14523 A 0	3908 6611 26	171 A 3 2 8 2
40139 0 0 10 14379 A 0	2409 6610 2	124 T 3 2 7 1
40162 0 0 14 3253 A 0	3511 6611 17	264 T 3 2 6 1
40164 24 7 14 14557 A 0	3210 6611 24	113 T 3 2 3 1
40209 20 3 23 14125 A 0	4404 6611 19	514 T 3 2 3 1
40214 0 0 04 2070 A 0	2404 4811 8	43 T 3 2 7 1
40251 3 0 4 14345 A 0	2609 6611 1	4 T 3 2 2 1
40524 0 0 6 2490 A 0	2610 6611 14	430 T 3 2 7 1
100263 24 4 12 437 A 0	4008 6611 16	14 A 3 2 4 2

1 0 0	0 0	100110101 000000	2 2 2 2 2 2	20 1100 1100
1 0	0 0	1101101 1 000000	2 2 2 2 2 2	20 1100 0100
1 0 0	0 0	100100101 000000	1 2 2 2 2 2	10 1100 0000
1 0 0	0 0	110110100 010110100	2 2 2 2 2 2	21 1100 0020
0 0	0 0 7	110100110 000000	1 2 2 2 2 2	00 1100 2000
1 0 0	0 0	000100 000000	1 2 2 2 2 2	01 1100 2100
1 0 0	0 0 1	000110100 000000	1 2 2 2 2 2	02 1100 0020
1 0 0	0 17 7	000000 000000	2 2 2 2 2 2	03 1100 0020
0 0	0 0	100100101 000000	2 2 2 2 2 2	00 1100 0020
0 0	0 0	110110111 000000	1 2 2 2 2 2	01 1100 0000
0 0	0 0 7	000000 000000	2 2 2 2 2 2	02 1100 0000
0 0	0 0	000000 000000	1 2 2 2 2 2	03 1100 0000
0 0	0 0	100100011 000000	1 2 2 2 2 2	04 1100 0020
0 0	0 12	000000 000000	2 2 2 2 2 2	05 1100 0020
1 1 0	0 0	000110100 000000	1 2 2 2 2 2	06 1100 0020
1 0 0	0 0	110110100 000000	1 2 2 2 2 2	07 1100 0020
1 0 0	0 0	110110100 000000	1 2 2 2 2 2	08 1100 0020
1 0 0	0 0	110110111 000000	1 2 2 2 2 2	09 1100 0020
1 1 0	0 2 17 3	000000 000000	1 2 2 2 2 2	10 1100 2010
1 0 0	0 1 20	000000 000000	2 2 2 2 2 2	01 1100 0000
1 0 0	0 1 7	110110110 000000	2 2 2 2 2 2	02 1100 0000
1 0 0	0 0	100100011 000000	2 2 2 2 2 2	03 1100 0000
1 0 0	0 0	100100101 000000	2 2 2 2 2 2	04 1100 0000
0 0	0 0	110110101 000000	2 2 2 2 2 2	05 1100 0000
0 0	0 0	110110111 000000	1 2 2 2 2 2	06 1100 0000

101459 26 11 20 1441 A
 101460 27 11 20 1442 A
 101461 28 11 20 1443 A
 101462 29 11 20 1444 A
 101463 30 11 20 1445 A
 101464 31 11 20 1446 A
 101465 12 11 20 1447 A
 101466 13 11 20 1448 A
 101467 14 11 20 1449 A
 101468 15 11 20 1450 A
 101469 16 11 20 1451 A
 101470 17 11 20 1452 A
 101471 18 11 20 1453 A
 101472 19 11 20 1454 A
 101473 20 11 20 1455 A
 101474 21 11 20 1456 A
 101475 22 11 20 1457 A
 101476 23 11 20 1458 A
 101477 24 11 20 1459 A
 101478 25 11 20 1460 A
 101479 26 11 20 1461 A
 101480 27 11 20 1462 A
 101481 28 11 20 1463 A
 101482 29 11 20 1464 A
 101483 30 11 20 1465 A
 101484 31 11 20 1466 A
 101485 12 11 20 1467 A
 101486 13 11 20 1468 A
 101487 14 11 20 1469 A
 101488 15 11 20 1470 A
 101489 16 11 20 1471 A
 101490 17 11 20 1472 A
 101491 18 11 20 1473 A
 101492 19 11 20 1474 A
 101493 20 11 20 1475 A
 101494 21 11 20 1476 A
 101495 22 11 20 1477 A
 101496 23 11 20 1478 A
 101497 24 11 20 1479 A
 101498 25 11 20 1480 A
 101499 26 11 20 1481 A
 101500 27 11 20 1482 A

0	0	0	0		110110015	000000	
0	0	0	0	7	00100111	000000	
1	1	0	0	0	110100015	000000	
1	1	0	0	0	000000	000000	
0	0	0	0		110110115	000000	
0	0	0	0		000000	000000	
0	0	0	0		010110101	000000	
1	0	0	0		000000	000000	
0	0	0	0	2	7	000000	000000
1	1	0	0	0		000000	000000
0	0	0	0		110110111	000000	
1	0	0	0		100100101	000000	
1	0	0	0		110000100	000000	
1	0	1	0	0		000000	000000
0	0	0	0	2	211	000000	000000
1	0	0	0		000000	000000	
1	0	0	0	7		000000	000000
0	0	0	0	7	0	000000	000000
0	0	0	0		100100105	000000	
1	0	0	0		000000	000000	
1	0	0	0	0		000000	000000
0	0	0	0		100100110	000000	
0	0	0	0		010110105	000000	
1	0	0	0		100100105	000000	
1	0	0	0		110110111	000000	

101450	5	10	10	101450	A	0
101470	8	10	10	101470	A	0
101511	18	7	0	101511	A	0
151150	10	7	00	151150	A	0
153312	22	11	16	0451	A	0
153981	1	1	16	0087	A	0
154841	41	3	98	270	A	0
155021	19	0	10	101	A	0
155272	1	1	15	208	A	0
157591	9	7	98	4592	A	0
157609	29	3	14	3610	A	0
157951	10	0	10	4160	A	0
158121	6	4	7	14747	A	0
158740	21	10	20	3947	A	0
159246	29	6	0	373	A	0
159285	6	10	1	4048	A	0
159300	10	10	00	456	A	0
159413	5	4	01	14220	A	0
159437	19	3	07	14440	A	0
200075	14	5	8	1	A	0
200112	17	10	16	4031	A	0
200162	9	3	12	4221	A	0
200204	21	11	18	3576	A	0
200226	10	2	12	4047	A	0
200251	2	1	16	14447	A	0
0105	6011	18				
108	A	7	2	6	2	
4305	6011	20				
108	A	7	2	7	2	
6210	6011	24				
207	A	7	2	6	2	
51	A	7	2	6	1	
10	A	7	2	0	1	
150	A	7	2	4	1	
176	A	7	2	7	2	
1204	614	49				
5610	4011	10				
1704	47	7	10			
1604	01	3	4			
4310	44	7				
0510	49	8	12			
2401	42	0	19			
4904	6011	13				
2604	65	6	10			
2605	6011	34				
2306	59	6	31			
4301	56	9	11			
2206	57	8	34			
0808	6011	14				
3307	6011	33				
4107	6011	05				
4702	6011	13				
4209	6011	24				
4801	6011	13				

0 0 0 0	1001001 000000	1 2 2 1 1 591	1
0 0 1 0	000000 000000	1 2 2 1 1 601	91
0 0 0 0	11010015 000000	1 2 2 1 1 609	90
0 0 0 0	10010010 000000	1 2 2 1 1 629	60
0 0 0 0	100100101 000000	1 0 2 1 1 70	11
0 0 0 0	110110011 000000	1 2 2 1 1 201	10
0 0 0 0	110110101 000000	1 0 2 1 1 201	10
0 EXH 0 0	000000 000000	1 2 2 1 1 001	90
0 0 0 0	100110010 000000	1 9 2 1 1 12	21
0 0 0 0	110100011 000000	1 0 2 1 1 11	01
0 0 0 1 71	000000 000000	1 9 2 1 1 000	01
0 0 0 0	000000 000000	1 9 2 1 1 100	10
0 0 0 0	110100101 000000	1 2 2 1 1 021	21
0 0 0 0	100100105 000000	0 2 2 1 1 022	11
0 0 0 0	110110115 000000	0 4 2 1 1 011	01
0 2 17 0 0	000000 000000	1 0 2 1 1 50	00
1 1 0 0 0 0	000000 000000	1 0 2 1 1 51	00
0 0 0 0	100100101 000000	0 0 2 1 1 010	10
0 0 0 0	100100011 000000	1 9 2 1 1 201	11
0 0 0 0 7 0	100100105 000000	1 0 2 1 1 002	20
1 0 0 0 1 7	000000 000000	1 1 2 1 1 022	20
1 0 1 7 0 1 77	000000 000000	1 2 2 1 1 201	10
0 0 0 0 0 0	000000 000000	1 2 2 1 1 01	00
1 0 0 0 0 0	110111105 000000	0 1 2 1 1 00	00
1 0 0 0 0 0	000000 01111010	0 2 2 1 1 001	00

1100 0000	0	A	0000	01	2	0	210000
1100 0001	0	A	0001	01	2	1	210001
1100 0002	0	A	0002	01	2	1	210002
1100 0003	0	A	0003	01	2	1	210003
1100 0004	0	A	0004	01	2	1	210004
1100 0005	0	A	0005	01	2	1	210005
1100 0006	0	A	0006	01	2	1	210006
1100 0007	0	A	0007	01	2	1	210007
1100 0008	0	A	0008	01	2	1	210008
1100 0009	0	A	0009	01	2	1	210009
1100 0010	0	A	0010	01	2	1	210010
1100 0011	0	A	0011	01	2	1	210011
1100 0012	0	A	0012	01	2	1	210012
1100 0013	0	A	0013	01	2	1	210013
1100 0014	0	A	0014	01	2	1	210014
1100 0015	0	A	0015	01	2	1	210015
1100 0016	0	A	0016	01	2	1	210016
1100 0017	0	A	0017	01	2	1	210017
1100 0018	0	A	0018	01	2	1	210018
1100 0019	0	A	0019	01	2	1	210019
1100 0020	0	A	0020	01	2	1	210020
1100 0021	0	A	0021	01	2	1	210021
1100 0022	0	A	0022	01	2	1	210022
1100 0023	0	A	0023	01	2	1	210023
1100 0024	0	A	0024	01	2	1	210024
1100 0025	0	A	0025	01	2	1	210025
1100 0026	0	A	0026	01	2	1	210026
1100 0027	0	A	0027	01	2	1	210027
1100 0028	0	A	0028	01	2	1	210028
1100 0029	0	A	0029	01	2	1	210029
1100 0030	0	A	0030	01	2	1	210030
1100 0031	0	A	0031	01	2	1	210031
1100 0032	0	A	0032	01	2	1	210032
1100 0033	0	A	0033	01	2	1	210033
1100 0034	0	A	0034	01	2	1	210034
1100 0035	0	A	0035	01	2	1	210035
1100 0036	0	A	0036	01	2	1	210036
1100 0037	0	A	0037	01	2	1	210037
1100 0038	0	A	0038	01	2	1	210038
1100 0039	0	A	0039	01	2	1	210039
1100 0040	0	A	0040	01	2	1	210040
1100 0041	0	A	0041	01	2	1	210041
1100 0042	0	A	0042	01	2	1	210042
1100 0043	0	A	0043	01	2	1	210043
1100 0044	0	A	0044	01	2	1	210044
1100 0045	0	A	0045	01	2	1	210045
1100 0046	0	A	0046	01	2	1	210046
1100 0047	0	A	0047	01	2	1	210047
1100 0048	0	A	0048	01	2	1	210048
1100 0049	0	A	0049	01	2	1	210049
1100 0050	0	A	0050	01	2	1	210050
1100 0051	0	A	0051	01	2	1	210051
1100 0052	0	A	0052	01	2	1	210052
1100 0053	0	A	0053	01	2	1	210053
1100 0054	0	A	0054	01	2	1	210054
1100 0055	0	A	0055	01	2	1	210055
1100 0056	0	A	0056	01	2	1	210056
1100 0057	0	A	0057	01	2	1	210057
1100 0058	0	A	0058	01	2	1	210058
1100 0059	0	A	0059	01	2	1	210059
1100 0060	0	A	0060	01	2	1	210060
1100 0061	0	A	0061	01	2	1	210061
1100 0062	0	A	0062	01	2	1	210062
1100 0063	0	A	0063	01	2	1	210063
1100 0064	0	A	0064	01	2	1	210064
1100 0065	0	A	0065	01	2	1	210065
1100 0066	0	A	0066	01	2	1	210066
1100 0067	0	A	0067	01	2	1	210067
1100 0068	0	A	0068	01	2	1	210068
1100 0069	0	A	0069	01	2	1	210069
1100 0070	0	A	0070	01	2	1	210070
1100 0071	0	A	0071	01	2	1	210071
1100 0072	0	A	0072	01	2	1	210072
1100 0073	0	A	0073	01	2	1	210073
1100 0074	0	A	0074	01	2	1	210074
1100 0075	0	A	0075	01	2	1	210075
1100 0076	0	A	0076	01	2	1	210076
1100 0077	0	A	0077	01	2	1	210077
1100 0078	0	A	0078	01	2	1	210078
1100 0079	0	A	0079	01	2	1	210079
1100 0080	0	A	0080	01	2	1	210080
1100 0081	0	A	0081	01	2	1	210081
1100 0082	0	A	0082	01	2	1	210082
1100 0083	0	A	0083	01	2	1	210083
1100 0084	0	A	0084	01	2	1	210084
1100 0085	0	A	0085	01	2	1	210085
1100 0086	0	A	0086	01	2	1	210086
1100 0087	0	A	0087	01	2	1	210087
1100 0088	0	A	0088	01	2	1	210088
1100 0089	0	A	0089	01	2	1	210089
1100 0090	0	A	0090	01	2	1	210090
1100 0091	0	A	0091	01	2	1	210091
1100 0092	0	A	0092	01	2	1	210092
1100 0093	0	A	0093	01	2	1	210093
1100 0094	0	A	0094	01	2	1	210094
1100 0095	0	A	0095	01	2	1	210095
1100 0096	0	A	0096	01	2	1	210096
1100 0097	0	A	0097	01	2	1	210097
1100 0098	0	A	0098	01	2	1	210098
1100 0099	0	A	0099	01	2	1	210099

0 0	0 0	100100101 000000
0 2	0 0	10010011 000000
0 0	0 1 1	000000 000000
0 0	0 1 7	000000 000000
0 0	0 7 0 11	000000 000000
0 1	0 1 0	000000 000000
0 1	0 0 1	110110111 000000
0 0	0 0	100100105 000000
0 2	0 0	000000 000000
0 0	0 0	100100105 000000
1 0	1 0	000100101 000000
0 0	0 0	000000 000000
0 0	0 0	100100105 000000
1 0 1 0	0 0 1	100100101 000000
0 0	0 0	110100101 000000
0 0	0 0	110110115 000000
0 1	0 0	100100101 000000
0 0	0 0	110110107 000000
0 0	0 1 7	110110011 000000
0 1	7 0 0	110100101 000000
0 1	7 0 0	000000 000000
0 0	0 0	110110015 000000
0 0	0 0	110110101 000000
0 0	0 0	100100101 000000
0 1	0 0 0	010010105 000000

0	0	0	0	1	110100101	000000
0	0	1	0		110110115	000000
0	0	0	0		100100105	000000
0	0	0	0		110110101	000000
0	0	0	0		100120101	000000
0	0	0	0		000000	000000
1	0	0	0		000000	000000
0	0	0	0		100100105	000000
0	0	0	0	0	000000	000000
0	0	0	0		110110111	000000
1	0	0	0		110110111	000000
0	0	0	0		100100105	000000
0	0	0	0		000000	000000
0	0	0	0		000000	000000
0	0	0	0	0	110110101	000000
0	0	0	0		111111115	000000
1	0	0	0		000000	000000
0	0	0	0		100100101	000000
0	0	0	0	0	100100105	000000
1	0	0	0	0	000000	000000
0	0	0	0	0	111111115	000000
1	0	0	0	0	000000	000000
0	0	0	0		110110011	000000
1	1	0	0	0	000000	000000
0	0	0	0		100100101	000000

302273	7	4	12	3475	A	0
302333	4	5	20	14746	A	0
35312H	1	5	11	3038	A	0
35313H	0	0	14	2927	A	0
353663	14	5	1	3227	A	1
353666	0	0	19	3562	A	0
354927	24	11	0	205	A	0
356054	5	5	14	412	A	0
356933	21	13	09	427	A	0
357204	0	0	4	1953	A	0
357363	14	2	34	3331	A	0
357723	0	0	15	14435	A	0
359140	19	9	18	3572	A	0
400163	21	10	15	229	A	0
400196	20	7	7	3533	A	0
400215	22	6	18	14445	A	0
400235	19	4	12	3361	A	0
400266	23	6	12	376	A	0
400359	14	4	19	441	A	0
450231	16	6	34	2753	A	0
500125	6	11	13	450	A	0
500141	9	9	13	1648	A	0
500194	21	7	9	1327	A	0
550122	24	11	07	14479	A	0
7003026	3	2	14	14435	A	0
2513	6611	33	419	T	3	2
7512	6611	33	446	T	3	2
4709	54	3	16	71	T	3
4209	42	9	5	65	T	3
4002	97	3	22	121	T	3
3911	39	8	23	171	T	3
4001	64	4	34	171	T	3
5109	50	7	7	4	T	3
356054	5	5	14	4	T	3
356933	21	13	09	264	T	3
357204	0	0	4	46	T	3
357363	14	2	34	46	T	3
357723	0	0	15	220	T	3
359140	19	9	18	153	T	3
400163	21	10	15	174	T	3
400196	20	7	7	375	T	3
400215	22	6	18	42	T	3
400235	19	4	12	707	T	3
400266	23	6	12	494	T	3
400359	14	4	19	65	T	3
450231	16	6	34	112	T	3
500125	6	11	13	2	T	3
500141	9	9	13	2	T	3
500194	21	7	9	1	T	3
550122	24	11	07	6902	T	3
7003026	3	2	14	25	T	3

[illegible]

1	1	0	0	0	000000	000000	1	2	2	1	1
0	0	0	0	0	100100101	000000	2	0	2	1	1
1	1	0	0	0	010010100	000000	2	0	2	1	1
0	0	0	0	0	010110111	000000	1	2	2	1	1
1	1	0	0	0	100100101	000000	1	2	2	1	1
0	0	0	0	0	000000	000000	1	2	2	1	1
1	0	0	0	0	000000	000000	1	2	2	1	1
0	0	0	2	77	100100101	000000	1	2	2	1	1
0	0	0	0	0	110110105	000000	2	2	2	1	1
1	0	0	0	0	010000101	000000	1	2	2	1	1
1	1	0	0	0	000000	000000	1	2	2	1	1
1	1	0	0	0	110110211	000000	1	2	2	1	1
1	0	0	0	0	010100101	010100210	1	2	2	1	1
1	0	0	1	77	000000	000000	1	2	2	1	1
0	0	0	0	0	100100015	000000	2	2	2	1	1
0	0	1	0	0	111111105	111111110	2	2	2	1	1
0	0	0	0	0	100100011	000000	1	2	2	1	1
0	0	0	10	0	000000	000000	1	2	2	1	1
1	1	1	7	0	2477	000000	000000	1	2	2	1
1	0	0	0	2	00	000000	000000	1	2	2	1
1	1	0	0	0	000000	000000	2	0	2	1	1
1	1	0	0	0	0	000000	000000	1	2	2	1
1	1	0	0	0	6	000000	000000	1	2	2	1
0	0	0	0	0	100100101	000000	1	2	2	1	1
1	0	0	0	0	110000111	000000	1	2	2	1	1

15944 25 1 04 1112 0 0 1 07 3004 00
35005 24 5 7 3307 0 0 141 112 0 0 34
51000 0 0 3 2615 0 0 102 2605 0 0 1 34
15300 5 6 5 47 0 0 145 511 0 0 2 34
15972 0 0 7 4000 0 0 1 142 2904 0 0 1 34
250025 10 10 10 112 0 0 1 153 4207 0 0 1 34
35178 05 0 17 14577 0 0 1 152 1512 0 0 1 34
352304 14 11 17 14202 0 20 145 1405 0 0 2 34
354421 23 4 30 2727 0 22 162 2402 0 0 2 34
356729 33 5 3 14230 0 0 145 2111 0 0 4 34
357707 21 4 0 1401 0 0 2 162 1706 0 0 4 34
155764 7 2 15 2735 0 0 2 161 416 0 0 2 34
251045 6 13 4 1457 0 0 1 14 4106 0 0 1 11
352001 0 0 0 200 0 0 1 145 2701 0 0 1 11
200727 25 10 0 0 0 0 1 145 2011 0 0 1 11
356134 21 2 0 1411 0 0 1 177 1305 0 0 1 44
159417 0 13 0 1507 0 0 0 141 2511 0 0 1 11
200234 4 1 11 155 0 27 104 212 0 0 1 34
355314 0 0 13 0 0 0 0 0 0 0 0 1 34
155030 21 4 2 2622 0 21 146 2300 0 0 2 34
157458 0 0 30 0 0 22 0 0 0 22 0 0 2 34
35519 0 4 14 0 0 0 0 0 0 0 0 1 34
159404 11 0 0 0 0 0 0 0 0 0 0 1 34
650024 11 0 0 0 0 0 0 0 0 0 0 1 34
15944 25 1 04 1112 0 0 1 07 3004 00

101436	4	4	2	4674	0	72	410	2604	6611	43	110	A	3	2	3	1
352244	1	0	36	1404	0	53	410	1404	47	4	22	1279	1	2	2	6
102773	17	6	17	14272	0	75	420	3708	6611	38	510	T	2	2	7	1
43036	12	4	2	3477	0	64	420	1710	62	2	49	172	A	1	2	7
50630	30	5	4	126	0	62	420	4304	47	1	1	52	T	1	2	9
20414	2	2	4	3494	0	75	420	2605	62	7	12	73	T	1	2	8
100147	74	4	17	3220	0	75	420	3503	6611	31	420	A	1	2	3	2
151212	13	6	12	4263	0	71	420	4906	60	4		2	A	1	2	0
151321	7	9	1	3471	0	51	420	4106	57	6	12	42	A	1	2	2
152641	2	5	10	14110	0	60	420	2702	63	6	23	441	A	3	2	7
154332	13	10	17	3521	0	73	420	2910	2217			10	A	1	2	3
154775	7	4	36	277	0	63	420	1107	61	0	42	203	A	2	2	8
154929	6	4	2	14271	0	59	420	1701	53	4	41	543	A	1	2	2
159351	10	5	6	3433	0	61	420	3705	61	2	74	67	A	1	2	6
159382	10	12	14	14204	0	66	420	1611	6103	25	1139	A	1	2	2	7
250272	5	0	2	14561	0	57	420	1309	4217	12	45	A	1	2	7	8
251354	21	12	0	248	0	58	420	2506	53	9	31	72	A	1	2	0
251156	25	4	0	14136	0	64	420	2505	52	4	27	25	A	1	2	7
300467	17	2	4	4472	0	67	420	5032	6611	16	117	T	1	2	0	1
303473	11	2	3	3434	0	75	420	3710	6611	34	344	T	1	2	7	1
301104	19	4	12	2636	0	67	420	3911	6611	27	123	T	1	2	7	1
301707	12	17	4	3475	0	71	420	1406	6611	44	1409	T	1	2	6	1
350124	1	4	40	1703	0	60	420	2807	60	1	77	1741	T	1	2	7
352384	4	6	4	2422	0	60	420	2104	61	5	36	434	T	1	2	6
352972	4	1	27	3232	0	64	420	1108	61	7	47	210	T	1	2	7

2m5

00	0	17	
100	0	0	
100	0	0	7
118	0	0	17
100	1	0	11
10	0	0	
00	1	17	
10	0	0	
00	0	0	
110	0	0	3
10	0	10	
100	0	0	
00	0	0	
00	0	70	
00	0	11	
00	0	0	
10	0	0	
00	0	0	0
100	0	0	0
00	0	2	70
00	0	0	
00	0	0	
00	0	0	
00	0	0	
00	0	17	

000000	000000	1 9 2 3 4 100	2 0 2 102 100 2 4 2 0001 00 0 00 20102
100000101	000000	1 0 2 3 4 200	2 1 1100 0001 000 2 4 0 000 0 0 0 0 00100
000000	000000	0 0 2 3 4 000	2 2 0 0 2001 000 000 0 0 0 0 0 0 00000
110110101	000000	1 0 2 3 4 200	2 3 1 0 2001 000 00 0 00001 0 0 0 0 00000
000000	000000	1 2 2 3 1 100	2 4 0 20 0001 000 12 0 2001 1 0 0 0 00000
110110011	000000	1 0 2 3 4 20	2 5 0 0 0001 000 000 2 0 0 0 0 0 00000
110110101	000000	1 2 2 3 1 21	2 6 0 1 1001 000 21 0 2101 00 0 0 0 00000
000000	000000	2 0 2 3 1 020	2 7 2 0 0101 000 00 0 000 21 0 0 0 00000
111111111	000000	1 0 2 3 4 020	2 8 0 0 0001 000 0 0 000 21 0 0 0 00000
110110110	000000	1 0 2 3 4 0211	2 9 0 0 0001 000 00 0 2001 00 1 0 00000
000000	000000	2 0 2 3 4 20	3 0 0 0 0001 000 00 0 000 20 0 0 0 00000
010011011	000000	2 0 2 3 4 12	3 1 0 0 0001 000 00 0 000 00 0 0 0 00000
000000	000000	1 2 2 3 1 001	3 2 1100 1001 000 02 0 0000 0 0 0 0 00000
110110101	000000	1 2 2 3 4 20	3 3 1100 2001 000 20 0 1000 0 0 00 00000
000000	000000	1 0 2 3 4 1000	3 4 2 0 00 200 000 00 0 00001 0 0 0 0 00000
110110011	000000	1 2 2 3 1 0000	3 5 0 0 00 1001 000 00 0 0000 10 0 00 00000
110110015	000000	1 2 2 3 4 100	3 6 1100 2000 000 02 0 00 101 0 0 0 0 00000
100100105	000000	1 0 2 3 4 1000	3 7 2 0 00 2000 000 10 0 000 0 0 0 0 00000
100100015	000000	1 0 2 3 4 110	3 8 0 0 00 2000 000 00 0 0000 0 1 00 00000
100100100	000000	1 0 2 3 4 00	3 9 0 0 00 0000 000 00 0 0000 00 1 00 00000
110110010	000000	2 0 2 3 4 200	4 0 2 0 00 1000 000 00 0 0000 1 0 0 0 00000
100100101	000000	1 0 2 3 4 1001	4 1 0 0 00 2000 000 00 0 0000 01 01 00 00000
100100105	0100100	1 0 2 3 4 20	4 2 1 00 1000 000 00 0 0000 00 0 0 00000
000000	000000	2 0 2 3 4 10	4 3 0 0 1000 000 02 0 0000 00 0 0 00000
000110105	000000	1 0 2 3 4 102	4 4 0 0 00 0001 000 02 0 00001 01 2 0 00000

0 0	0	1 7	000000	000000
1 0 0	0	0	100000101	000000
1 0 0	0	0 7	000000	000000
1 1 x	0 0	1 7	110110111	000000
1 0 0	1	0 0	000000	000000
1 0	0	0	110110111	000000
0 0	1	1 7	110110111	000000
1 0	0	0	000000	000000
0 0	0	0	111111111	000000
1 1 0	0	0	010110110	000000
1 0	0	1 0	000000	000000
1 0 0	0	0	010011011	000000
0 0	0	0	000000	000000
0 0	0	7 0	110110101	000000
0 0	0	1 1	000000	000000
0 0	0	0	110110111	000000
1 0	0	0	110110015	000000
0 0	0	0 0	100100105	000000
1 0 0	0	0 0	100100015	000000
0 0	0	2 7 0	100100101	000000
0 0	0	0	110110010	000000
0 0	0	0	100100101	000000
0 0	0	0	100100105	010010100
0 0	0	0	000000	000000
0 0	0	1 1 7	000110105	000000

354457 6 7 19 1623 0 76 420 3509 64 9 39 710 1 3 2 3 1
 355513 4 6 39 498 0 70 423 3803 58 7 2 1 3 2 3 2
 356311 10 7 06 273 0 56 420 2301 58 4 33 49 1 3 2 6 1
 356459 27 10 14 4353 0 63 420 4702 63 5 16 343 1 3 2 4 1
 357352 7 6 1 3347 0 69 420 2906 64 7 35 492 1 3 2 3 2
 358136 22 1 09 3246 0 66 423 2308 56 8 36 24 1 3 2 3 1
 358426 18 1 9 3597 0 66 420 2702 66 6 31 413 1 3 2 6 1
 359546 9 12 8 438 0 61 420 2207 61 7 34 2641 1 3 2 6 1
 402264 12 2 0 14156 0 71 420 2407 6411 42 203 1 3 2 7 1
 450120 24 4 01 2740 0 53 423 1501 57 6 39 4356 1 3 2 7 1
 450374 5 4 03 14757 0 68 420 407 60 7 49 665 1 3 2 6 1
 603067 25 4 9 2051 0 67 420 5007 6611 16 32 1 3 2 7 1
 12505 11 6 2 4034 0 74 423 1601 6611 35 130 1 3 2 7 1
 150747 27 6 06 27 0 54 422 2903 5719 39 73 4 3 2 6 2
 153263 6 13 97 363 0 69 423 2111 6210 32 47 4 3 2 6 3
 156466 4 1 03 14472 0 56 422 1303 56 5 43 1176 4 3 2 3
 250425 7 5 12 2630 0 55 422 4209 55 8 9 72 4 3 2 4 1
 352254 14 6 17 756 0 52 422 3510 59 7 16 279 1 3 2 6 2
 355662 11 5 04 14177 0 67 422 1401 41 5 5 17 1 3 2 2 1
 750198 25 4 2 2 0 47 434 5610 60 6 3 7 1 3 2 2 1
 950220 27 12 01 4767 0 71 433 4906 57 9 7 93 1 3 2 7 1
 358324 23 9 2 14493 0 59 443 2606 59 1 31 467 1 3 2 0 1
 403356 21 5 04 14152 0 65 450 1407 59 4 37 593 1 3 2 3 2
 40145 11 6 4 413 0 67 466 2609 6011 43 467 1 3 2 0 1
 252157 24 9 32 14563 0 65 491 705 57 0 39 541 4 3 2 6 1

0 0	0 0	110110105	000000
1 1 0	0 0	110110111	000000
1 0 0	0 0	000000	000000
0 0	0 0	110111111	000000
0 0	0 7 0	000000	000000
1 0 0	0 1 7	000000	000000
0 0	0 1 0	000000	000000
1 0 1	0 0 0 7	110100110	000000
1 0 0	0 0	100100105	000000
1 0 0	0 0	110100110	000000
0 0	0 0	010110105	000000
1 0 0	0 0	110110105	000000
1 0	0 0	100000101	000000
0 1 7 0	0 1 7	100100101	000000
0 0	0 1 7	110110211	000000
0 0	0 0 0	110110011	000000
1 0	0 7 0	110111100	000000
1 0 0	0 0	100100105	000000
1 0	0 0	111111110	000000
1 0 0	0 0	000110100	000000
1 0 0	0 0	000000	111111
0 0	1 1 1	110111225	000000
0 0	0 0 1	000000	000000
1 0 0	0 0 0	000000	000000
1 0 0	0 0 0	000000	000000

COHORT "B"

Reader 4

"Normals"

pp. 250 - 268

"Less-than-normals"

pp. 269 - 281

[illegible]

[illegible]

90004	0	0	17	8400	A	0	7004	6-11	27	174	A	1
90106	0	0	20	8640	A	0	4501	6-11	12	42	T	1
90150	15	0	14	8730	A	0	3200	6-11	20	209	T	1
90171	0	0	13	14000	A	0	3100	6-11	20	68	T	1
90204	14	5	13	8000	A	0	2000	6-11	27	120	T	1
90240	0	0	10	14000	A	0	2410	6-11	7	74	T	1
90252	24	0	12	13430	A	0	0411	6-11	21	070	T	1
90255	2	1	0	7000	A	0	0511	6-11	11	52	T	1
90301	27	1	14	14200	A	0	1611	6-11	5	18	A	1
90373	16	0	12	0300	A	0	1011	6-11	25	704	A	1
90398	0	0	0	4500	A	0	2011	6-11	24	79	T	1
100301	20	1	10	9330	A	0	2512	6-11	31	225	A	1
100303	25	5	0	4000	A	0	2703	6-11	20	142	A	1
100313	24	11	14	1350	A	0	4007	6-11	20	36	A	1
100314	25	0	10	14000	A	0	4205	6-11	13	56	A	1
100339	14	1	0	8100	A	0	4000	6-11	17	53	A	1
100317	26	0	10	0300	A	0	4000	6-11	17	70	A	1
100323	0	0	13	4100	A	0	4100	6-11	25	131	A	1
100340	12	11	10	4300	A	0	5306	6-11	12	0	A	1
100372	21	0	10	4620	A	0	4507	6-11	31	127	A	1
100503	11	11	20	4300	A	0	4511	6-11	20	107	A	1
100527	2	1	20	13000	A	0	3012	6-11	20	704	A	1
100557	16	2	10	0300	A	0	4012	6-11	30	30	A	1
100583	27	2	10	13000	A	0	4704	6-11	13	0	A	1
100584	28	10	0300	A	0	4810	6-11	21	0	0	A	1

[illegible]

[illegible]

[illegible]

[illegible]

0	0	0	0	000000	000000
1	0	0	0	000000	000000
2	0	0	0	000000	000000
3	0	0	0	000000	000000
4	0	0	0	000000	000000
5	0	0	0	000000	000000
6	0	0	0	000000	000000
7	0	0	0	000000	000000
8	0	0	0	000000	000000
9	0	0	0	000000	000000
10	0	0	0	000000	000000
11	0	0	0	000000	000000
12	0	0	0	000000	000000
13	0	0	0	000000	000000
14	0	0	0	000000	000000
15	0	0	0	000000	000000
16	0	0	0	000000	000000
17	0	0	0	000000	000000
18	0	0	0	000000	000000
19	0	0	0	000000	000000
20	0	0	0	000000	000000
21	0	0	0	000000	000000
22	0	0	0	000000	000000
23	0	0	0	000000	000000
24	0	0	0	000000	000000
25	0	0	0	000000	000000
26	0	0	0	000000	000000
27	0	0	0	000000	000000
28	0	0	0	000000	000000
29	0	0	0	000000	000000
30	0	0	0	000000	000000
31	0	0	0	000000	000000
32	0	0	0	000000	000000
33	0	0	0	000000	000000
34	0	0	0	000000	000000
35	0	0	0	000000	000000
36	0	0	0	000000	000000
37	0	0	0	000000	000000
38	0	0	0	000000	000000
39	0	0	0	000000	000000
40	0	0	0	000000	000000
41	0	0	0	000000	000000
42	0	0	0	000000	000000
43	0	0	0	000000	000000
44	0	0	0	000000	000000
45	0	0	0	000000	000000
46	0	0	0	000000	000000
47	0	0	0	000000	000000
48	0	0	0	000000	000000
49	0	0	0	000000	000000
50	0	0	0	000000	000000
51	0	0	0	000000	000000
52	0	0	0	000000	000000
53	0	0	0	000000	000000
54	0	0	0	000000	000000
55	0	0	0	000000	000000
56	0	0	0	000000	000000
57	0	0	0	000000	000000
58	0	0	0	000000	000000
59	0	0	0	000000	000000
60	0	0	0	000000	000000
61	0	0	0	000000	000000
62	0	0	0	000000	000000
63	0	0	0	000000	000000
64	0	0	0	000000	000000
65	0	0	0	000000	000000
66	0	0	0	000000	000000
67	0	0	0	000000	000000
68	0	0	0	000000	000000
69	0	0	0	000000	000000
70	0	0	0	000000	000000
71	0	0	0	000000	000000
72	0	0	0	000000	000000
73	0	0	0	000000	000000
74	0	0	0	000000	000000
75	0	0	0	000000	000000
76	0	0	0	000000	000000
77	0	0	0	000000	000000
78	0	0	0	000000	0

[illegible]

159117	18	5	17	8127	A	0
159159	15	2	30	8427	A	0
159155	27	4	00	8217	A	0
159219	14	13	13	8501	F	0
159240	4	10	10	8410	A	0
159258	27	1	17	8403	A	0
159403	19	5	11	1426	A	0
159475	19	11	14	1415	A	0
159567	24	4	19	8410	A	0
159597	15	2	16	8574	A	0
159618	2	7	14	8284	A	0
159643	22	4	17	1402	A	0
159654	10	7	10	8400	A	0
159736	17	4	8	1364	A	0
159844	20	7	15	8511	A	0
159150	21	13	11	1500	A	0
159749	27	11	20	1447	A	0
159734	23	4	10	8214	A	0
159745	7	3	25	7267	A	0
159759	24	2	30	8300	A	0
159801	11	13	12	8404	A	0
159814	13	2	34	8474	A	0
159817	2	13	12	1444	A	0
159859	19	5	27	1351	A	0
200394	41	7	11	8227	A	0
2302	31	2				
4200	31	2				
5007	4011	11				
6206	7330	2				
8205	7330	2				
8408	8410	4				
8508	8410	4				
8604	8410	4				
8700	8410	4				
8804	8410	4				
8904	8410	4				
9004	8410	4				
9104	8410	4				
9204	8410	4				
9304	8410	4				
9404	8410	4				
9504	8410	4				
9604	8410	4				
9704	8410	4				
9804	8410	4				
9904	8410	4				

251651	3	5 11	4456	A	0	4907	59 1	8	A	A	A	1	6	1
251673	29	9 16	4667	A	0	4003	45 7	5	44	A	A	1	0	1
251039	8	7 11	15037	A	0	3705	47 5	10	213	A	A	1	0	1
252298	21	3 17	4536	A	0	A	4	1	0	1				
300002	21	2 17	9778	A	0	4306	6611	21	483	T	A	1	7	1
300306	41	1 20	13983	A	0	5211	6611	13	58	T	A	1	1	1
300330	29	12 19	13730	A	0	6399	6611	13	97	T	A	1	8	1
300358	5	13 16	4540	A	0	4936	6611	28	406	T	A	1	7	1
300159	22	11 15	4662	A	0	3702	6611	23	455	T	A	1	4	1
300184	21	4 20	9928	A	0	5208	6611	14	24	T	A	1	7	1
300139	21	3 13	14944	A	0	5205	6611	14	40	T	A	1	7	1
300246	23	6 17	13764	A	0	3966	6611	26	207	T	A	1	5	0
300247	13	12 16	4603	A	0	2904	6611	27	439	T	A	1	2	1
300298	29	9 19	13507	A	0	3309	6611	22	394	T	A	1	7	1
300329	15	8 14	4651	A	0	2801	6611	18	774	T	A	1	5	1
300337	2	1 10	15022	A	0	4208	6611	24	103	T	A	1	1	1
300419	29	4 16	4617	A	0	3610	6611	10	933	T	A	1	4	1
300490	21	6 18	14702	A	0	4305	6611	23	433	T	A	1	6	1
300511	4	9 16	4616	A	0	4101	6611	21	135	T	A	1	0	1
300530	17	12 13	14464	A	0	4204	6611	24	731	T	A	1	5	1
300539	6	3 14	4014	A	0	3612	6611	20	1070	T	A	1	5	1
300562	41	12 18	7903	A	0	4610	6611	21	362	T	A	1	6	1
300585	12	1 9	4531	A	0	2007	6611	19	124	T	A	1	4	1
300605	6	12 20	14316	A	0	3909	6611	26	132	T	A	1	7	0
300659	14	7 15	15108	A	0	4105	6611	25	1075	T	A	1	7	1

652

[illegible]

[illegible]

353041	7	0	0	14764	A	0	2702	54	0	53	37	T
353070	14	0	13	4530	A	0	4011	17	0	13	100	T
353079	4	0	10	4507	A	0	4001	1	0	7	10	T
353081	21	11	0	4340	A	0	3211	04	0	17	762	T
353107	18	0	0	4378	A	0	2600	04	0	30	513	T
353150	11	0	10	1350	A	0	0807	59	0	0	4	T
353161	0	1	17	4010	A	0	3011	58	0	30	004	T
353071	0	0	10	2000	A	0	4710	04	0	16	930	T
353047	05	0	17	4000	A	0	4710	44	0	0	37	T
353075	0	0	10	1502	A	0	1702	42	0	0	12	T
353120	0	0	7	4700	A	0	1000	47	0	17	331	T
353070	06	0	10	4611	A	0	2002	00	11	17	100	T
353076	1	0	20	0017	A	0	3707	00	11	10	06	T
353100	27	2	00	2000	A	0	4000	00	11	10	407	T
353100	0	11	10	4600	A	0	3600	00	11	10	331	T
353100	10	0	10	2000	A	0	4000	00	11	10	400	T
353100	11	10	10	1000	A	0	3000	00	11	10	110	T
353070	1	0	10	4000	A	0	4010	00	11	10	106	T
353070	0	0	10	4000	A	0	2001	00	11	10	070	T
353000	28	10	2	0000	A	0	4011	00	11	10	100	T
353070	15	0	11	4100	A	0	4000	00	11	10	100	T
353070	16	0	10	1000	A	0	4000	00	11	10	200	T
353070	21	10	10	1000	A	0	2100	00	11	10	100	T
353070	15	0	0	1000	A	0	3000	00	11	10	100	T
353070	1	0	00	4100	A	0	4002	00	11	10	000	T

[illegible]

353186	21	10	20	1358	A	0	4705	64	9	17	25	1	4	1	4	1
354118	2	7	20	1362	A	0	4106	64	9	16	423	1	4	1	9	1
354750	0	0	12	1400	A	0	1909	4111	1	10	1	4	1	4	1	1
355047	7	5	20	1359	A	0	4408	46	9	2	17	1	4	1	7	1
356792	0	0	19	4431	A	0	3811	42	7	3	173	1	4	1	2	1
357457	0	0	17	1351	A	0	4603	50	6	4	25	1	4	1	7	1
357520	14	5	4	4407	A	0	5804	5812		1	1	4	1	2	1	
358409	24	11	08	1363	A	0	2106	64	7	32	427	1	4	1	2	1
359584	31	3	20	9175	A	0	4535	6113		7	1	4	1	7	1	
400009	17	10	20	4589	A	0	4703	6611	19	459	1	4	1	3	1	
400149	14	4	14	4254	A	0	4712	6611	17	21	1	4	1	4	1	
400177	24	2	0	4298	A	0	2901	6611	29	49	1	4	1	3	1	
400217	22	1	14	1489	A	0	3710	6611	29	251	1	4	1	7	1	
400439	10	6	17	1403	A	0	4703	6611	18	39	1	4	1	7	1	
400456	29	8	17	4440	A	0	3710	6611	29	493	1	4	1	6	1	
450716	29	5	19	4267	A	0	1908	47	3	174	1	4	1	2	1	
500324	17	4	19	4245	A	0	6511	6611	1	6	1	4	1	2	1	
600091	25	10	20	8425	A	0	5606	6611	5	85	1	4	1	8	1	
650950	2	4	19	13575	A	0	4706	4811	1	12	1	4	1	7	1	
650963	23	3	19	13934	A	0	5507	52	9	2	24	1	4	1	7	2
650140	31	7	12	7919	A	0	4703	6011	3	55	1	4	1	2	2	
650587	1	12	14	8947	A	0	4608	4910		1	4	1	6	1		
650691	32	6	17	15021	A	0	4609	47	1	13	1	4	1	7	2	
700001	4	4	13	8107	A	0	5908	6611	7	14	1	4	1	4	1	
700021	2	7	14	8158	A	0	5405	6611	12	15	1	4	1	7	1	

[illegible]

[illegible]

[illegible]

[illegible]

74 26 4 4 1401 0 7 403 307 57 2 15
 104 35 0 15 1445 0 6 1 424 4504 43 7 4
 113 32 7 16 14011 0 47 423 4704 44 2
 53549 12 10 32 4326 0 20 423 2806 4017 32
 50433 5 0 37 14745 0 64 423 804 64 5 0
 40233 27 0 4 14446 0 52 420 1404 47 4 37
 49556 11 10 31 4430 0 53 420 2507 48 0 14
 49355 30 2 0 4414 0 43 420 1742 63 4 39
 100572 17 5 14 14646 0 21 420 473 4411 13
 131227 15 3 10 4437 0 65 420 2011 6411 14
 101233 3 4 10 14937 0 27 420 3405 4411 31
 101563 11 11 7 2036 0 21 420 4403 6611 10
 101740 17 0 5 13004 0 69 420 3637 6441 33
 150500 0 0 0 4404 0 24 420 2204 38 0 36
 141264 3 5 34 14653 0 27 420 4207 6710 13
 141744 12 1 32 4330 0 47 420 2510 47 0 17
 153647 1 10 11 14444 0 22 420 2410 44 2
 152465 14 11 10 4334 0 23 420 5602 44 7 0
 154569 4 5 14 4744 0 21 420 4104 4413 0
 154582 14 7 14 2444 0 64 420 3205 49 5 4
 15474 15 10 7 4433 0 23 420 4504 4013 15
 154432 5 7 11 14234 0 67 420 2834 67 1 34
 154564 20 0 32 4456 0 50 420 3904 42 1 30
 154524 14 4 10 4331 0 23 420 6705 44 1 1
 155003 15 10 10 4446 0 50 420 3011 42 0 13
 154441 1 1 1

[illegible]

155407 13 7 19 8074 0 67 420 4308 67 9 20 159 A 4 1 9 2
 155404 10 10 9 8656 0 61 420 3505 43 7 150 A 4 1 7 1
 156173 22 7 2 7995 0 55 420 2001 49 9 20 756 A 4 1 5 1
 156506 5 9 15 8600 0 66 420 4107 43 4 1 A 4 1 5 1
 156718 3 5 2 14971 0 58 420 4806 4411 1 A 4 1 7 1
 157131 4 7 19 8271 0 74 420 4906 43 7 A 4 1 7 1
 159180 20 3 5 4570 0 65 420 3005 44 8 16 930 A 4 1 8 1
 159255 19 12 91 13367 0 74 420 911 56 1 33 424 A 4 1 2 2
 159465 13 9 8 4147 0 74 420 4704 62 5 14 65 A 4 1 2 2
 251734 19 12 1 9710 0 72 420 2212 6610 25 45 A 4 1 0 1
 252175 27 10 4 4122 0 47 420 4305 47 2 2 9 A 4 1 9 1
 301569 26 5 12 4468 0 67 420 2809 6611 38 262 1 4 1 5 1
 351164 21 8 93 4522 0 72 420 1508 64 4 43 431 1 4 1 7 1
 351210 30 3 95 4037 0 62 420 2610 53 3 24 389 1 4 1 7 2
 352102 6 5 12 14748 0 57 420 2905 57 4 27 340 1 4 1 7 2
 353532 3 0 99 4930 0 67 420 2707 23 3 1 4 1 7 1
 357691 14 10 91 13731 0 73 420 2508 5910 24 1227 1 4 1 2 1
 357692 8 6 9 13774 0 62 420 2808 6212 27 243 1 4 1 7 1
 355574 5 8 2 4204 0 74 420 2606 64 6 32 219 1 4 1 8 1
 356495 7 11 12 7854 0 74 420 4206 64 7 22 297 1 4 1 7 1
 450571 13 10 95 13570 0 63 420 2201 63 5 41 2976 1 4 1 9 1
 650318 26 9 10 4630 0 72 420 4601 52 5 6 16 1 4 1 7 1
 950181 16 7 94 14657 0 57 420 4007 5412 14 454 1 4 1 7 1
 502237 9 13 94 8641 0 74 420 2005 53 1 32 933 1 4 1 0 1
 100118 20 3 15 4144 0 67 420 4906 6611 17 106 A 4 1 7 2

[illegible]

155407 10 7 10 2074 0 60 420 4302 67 8 20 169 A 4 1 9 2
 154404 10 10 0 3656 0 61 420 3505 43 7 150 A 4 1 7 1
 156173 22 7 2 7985 0 55 420 2001 49 9 20 756 A 4 1 5 1
 156506 5 9 16 3630 0 66 420 4107 43 4 1 A A 4 1 5 1
 156718 3 5 2 14071 0 58 420 4806 4811 1 A 4 1 7 1
 157131 4 7 18 9271 0 74 420 4906 49 7 A 4 1 7 1
 159180 20 3 5 4570 0 65 420 3005 46 3 16 A 4 1 7 1
 159255 19 12 01 14367 0 74 420 911 56 1 33 424 A 4 1 2 2
 159465 13 9 8 4187 0 74 420 4704 52 5 14 65 A 4 1 2 2
 251734 19 42 1 4210 0 72 420 2212 6610 25 45 A 4 1 0 1
 252175 27 10 4 4322 0 47 420 4405 47 2 7 9 A 4 1 9 1
 301568 26 5 12 4468 0 67 420 2009 6611 38 262 T 4 1 5 1
 351164 21 8 92 4592 0 72 420 1508 64 4 43 441 T 4 1 7 1
 351710 30 3 05 4697 0 62 420 2610 53 3 24 789 T 4 1 7 2
 352192 6 5 12 14748 0 57 420 2905 57 4 27 340 T 4 1 7 2
 353572 0 0 00 4800 0 67 420 2307 23 4 T 4 1 7 1
 357493 14 10 01 14731 0 73 420 2908 5910 24 1227 T 4 1 2 1
 357762 4 6 0 13774 0 62 420 2808 6212 27 243 T 4 1 7 1
 358574 5 9 2 4204 0 74 420 2606 64 6 32 219 T 4 1 9 1
 356695 7 11 12 7054 0 74 420 4206 64 7 22 207 T 4 1 7 1
 450571 13 13 05 15670 0 61 420 2201 63 5 41 2076 T 4 1 9 1
 650018 26 9 10 4670 0 72 420 4501 52 6 6 16 T 4 1 7 1
 950181 16 7 04 14557 0 54 420 4007 5312 13 454 T 4 1 7 1
 500237 9 12 94 2641 0 74 420 2705 53 1 32 933 T 4 1 0 1
 100113 20 9 15 4144 0 61 420 4004 5011 17 104 A 4 1 7 2

[illegible]

251 449 17 4 2 15045 D 74 422 2406 44 3 14
 151739 29 10 04 4704 D 74 422 2509 59 5 23
 155404 22 4 2 15074 D 64 422 4208 49 2 3
 159440 26 7 34 4524 D 72 424 1010 60 7 44
 353633 0 0 96 4062 D 64 446 1411 19 1
 153094 3 4 6 4504 D 75 450 4608 4612
 151775 21 5 19 4775 D 65 491 3705 65 1 27
 40245 14 2 12 4264 D 74 521 2603 6611 19
 101603 6 9 4 4609 D 70 523 3706 6611 29
 155025 14 6 94 14409 D 57 527 2201 5710 31
 150499 10 4 19 4709 D 66 572 4405 44 8 2
 150445 25 5 2 4768 D 67 541 1612 5612 24
 153130 14 1 14 4777 D 66 581 4306 44 4 4
 200201 13 3 4 4657 D 75 591 4310 6611 21
 353944 11 1 14 4659 D 66 591 3306 57 7 20
 157474 25 4 2 4510 D 64 545 4107 4611 5
 150051 27 7 93 14913 D 74 585 2305 32 5 9
 151956 26 2 12 13642 D 70 587 2611 4711 11
 151797 12 1 4 4391 D 63 612 4112 44 7 6
 40275 3 1 95 4974 D 65 745 1704 46 3 4
 650715 2 4 92 13662 D 71 792 4507 49 1 3
 154247 4 4 9 13678 D 60 810 4702 5012 3
 352540 27 4 17 4475 D 74 813 4708 4911 4
 150824 20 9 16 13750 D 38 812 3613 49 9 1
 154096 31 3 6 14003 D 64 812 4904 49 7
 4 4 1 7 1
 36 4 4 1 7 1
 25 1 4 1 7 1
 34 4 4 1 6 1
 36 1 4 1 7 1
 40 4 4 1 7 1
 18 4 4 1 2 1
 29 4 4 1 9 1
 163 4 4 1 0 1
 130 4 4 1 6 1
 1754 4 4 1 7 1
 47 4 4 1 7 2
 15 4 4 1 4 1
 975 4 4 1 7 1
 32 4 4 1 9 1
 1031 4 4 1 2 2
 265 4 4 1 6 1
 269 1 4 1 3 1
 68 4 4 1 4 1
 4 4 4 1 6 1
 1 4 1 2 2
 694 4 4 1 9 2
 12 1 4 1 7 1
 216 1 4 1 6 1
 43 4 4 1 2 1

[illegible]

90181	10	3	15	14256	A	0
90184	0	0	0	49002	A	0
90187	7	7	20	13744	A	0
90035	0	0	00	4455	A	0
40051	7	0	43	4546	A	0
40055	0	0	15	13762	A	0
40060	0	0	11	14204	A	0
40063	14	0	14	1451	A	0
40070	40	11	4	1467	A	0
50055	27	5	13	14757	A	0
50560	28	5	20	4431	A	0
50571	21	4	5	4034	A	0
50627	24	4	15	14706	A	0
50774	0	0	16	4470	A	0
50137	12	7	27	13625	A	0
40165	0	0	0	4036	A	0
40177	0	0	14	14654	A	0
10044	4	7	5	7267	A	0
10417	21	3	10	14444	A	0
10115	25	4	0	4324	A	0
10020	0	0	17	4133	A	0
10035	10	1	5	4027	A	0
10034	1	7	0	4520	A	0
2701	0	0	11	13447	A	0
2005	44	4	14	7074	A	0
709	4	4	2	0		
709	4	4	2	0		
2703	6411	20				
4709	6411	14				
2012	6411	45				
4410	6411	21				
2603	6411	42				
3603	6411	17				
4510	6411	14				
3701	6411	7				
1806	6411	11				
1300	6411	14				
3702	6410	12				
1703	3311	1				
2202	3311	23				
4601	6311	2				
3601	654	19				
2304	505	25				
4229	6411	18				
3707	6411	34				
3704	6411	37				
413	1411	31				
104	1411	41				
102	1411	10				
4510	6411	12				
2511	6411	35				
4612	6411	37				

[illegible]

93109	0	0	14	1472	A	0	7608	6611	27	122	1	4	2	4	1
90215	0	0	30	4977	A	0	3710	6611	28	124	1	4	2	4	1
40219	1	7	16	1361	A	0	4004	6611	17	43	4	4	2	4	2
100332	17	6	17	14839	A	0	3711	6611	30	212	4	4	2	4	2
100313	13	4	12	8767	A	0	3407	6611	32	439	4	4	2	4	1
100352	24	7	4	4374	A	0	4404	6611	14	42	4	4	2	4	1
100104	5	4	16	4235	A	0	3707	6611	29	205	4	4	2	4	2
100114	1	7	15	7944	A	0	4710	6611	19	30	4	4	2	4	1
100324	26	10	12	13639	A	0	3211	6611	33	145	4	4	2	4	2
100277	5	4	19	4524	A	0	4608	6611	30	117	4	4	2	4	2
100132	23	3	10	4242	A	0	3411	6611	26	510	4	4	2	4	1
100341	15	5	18	4478	A	0	4010	6611	16	14	4	4	2	4	1
100424	21	4	12	4227	A	0	3504	6611	21	274	4	4	2	4	2
100315	12	13	14	13614	A	0	4206	6611	24	436	4	4	2	4	1
100544	30	6	12	1473	A	0	3704	6611	20	110	4	4	2	4	1
100485	4	5	13	14744	A	0	4304	6611	22	194	4	4	2	4	1
100547	22	7	14	14037	A	0	4405	6611	23	37	4	4	2	4	2
100614	27	3	13	7144	A	0	2910	6611	13	344	4	4	2	4	1
100672	4	1	11	7304	A	0	5211	6611	14	7	4	4	2	4	2
100666	20	10	14	14644	A	0	3707	6611	20	30	4	4	2	4	2
100600	22	10	10	12	7071	A	0	3606	6611	25	363	4	4	2	1
100626	1	2	1	4534	A	0	4112	6611	26	340	4	4	2	4	1
100615	11	11	10	7323	A	0	5006	6611	14	1	4	4	2	4	1
100647	14	2	20	8744	A	0	3911	6611	22	147	4	4	2	4	1
100600	19	13	14	4224	A	0	4401	6611	23	147	4	4	2	4	1

1	0	0	0	000000	000000	1	0	2	0	0
0	0	0	0	100100101	000000	1	0	2	0	0
1	1	0	0	000000	000000	1	1	2	0	0
0	1	0	0	000000	000000	1	1	2	0	0
1	1	0	0	000000	000000	1	1	2	0	0
1	0	0	0	000000	000000	2	0	2	0	0
0	0	0	0	000000	110110101	1	1	2	0	0
1	0	0	0	111111201	000000	2	1	2	0	0
1	1	0	0	000000	000000	1	0	2	0	0
0	0	0	0	000000	010010010	1	1	2	0	0
1	0	0	0	000000	000000	1	1	2	0	0
0	0	0	0	100100101	000000	2	1	2	0	0
0	0	0	0	100100101	000000	1	1	2	0	0
0	0	0	0	110110110	000000	2	1	2	0	0
1	0	0	0	000000	000000	1	1	2	0	0
0	0	0	0	110110211	000000	1	1	2	0	0
0	0	0	0	000000	010010021	2	0	2	0	0
0	0	0	0	110110220	000000	2	1	2	0	0
0	0	0	0	110110110	000000	1	1	2	0	0
0	0	0	0	110110111	000000	2	1	2	0	0
0	0	0	0	110100110	000000	2	1	2	0	0
0	0	0	0	110110111	000000	2	1	2	0	0
0	0	0	0	110110111	000000	1	1	2	0	0
1	0	0	0	110110110	000000	1	1	2	0	0
1	0	0	0	110110110	000000	1	1	2	0	0

100551 10	0	12	1450	A	0	4301 5511 33		
101106 1	0	4	14	14315	A	0	4204 6511 24	
101470 14	0	4	4170	A	0	2407 6511 12		
101398 19	0	3	23	4206	A	0	4706 6511 13	
101520 4	0	12	13	14029	A	0	4810 6511 14	
101522 24	0	2	4	4734	A	0	2507 6511 40	
101584 25	0	5	2	15030	A	0	4303 6511 23	
101625 15	0	5	19	14027	A	0	4607 6511 13	
102736 21	0	7	12	4414	A	0	3621 45 7 4	
151716 24	0	4	12	17014	A	0	4805 45 2 2	
152044 7	0	1	7	14604	A	0	2305 45 7 26	
152410 10	0	4	17	13504	A	0	4305 45 4 5	
153413 15	0	2	12	4414	A	0	2012 44 7 14	
155143 23	0	2	12	14227	A	0	3406 45 5 12	
155253 21	0	4	1	17156	A	0	2004 45 3 27	
155662 12	0	12	12	7	4031	A	0	2604 6512 24
156111 3	0	4	19	4514	A	0	5204 54 7 5	
156346 24	0	6	14	4432	A	0	5102 55 6	
156541 17	0	4	4	14563	A	0	5002 55 7	
157226 7	0	6	14	4432	A	0	4110 45 2	
157930 31	0	1	12	4444	A	0	4401 55 5 7	
157473 23	0	11	7	12763	A	0	4802 55 4 2	
159255 11	0	12	19	4515	A	0	4402 55 4 1	

0 0 7 0 0	000000	000000
0 0 0 0 0	100100105	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	100100111	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	100100101	000000
0 0 0 0 0	100100015	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	110100111	000000
0 0 0 0 0	100100011	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	100100101	000000
0 0 0 0 0	100100101	000000
0 0 0 0 0	110100111	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	100100101	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	110100115	000000
0 0 0 0 0	000000	000000
0 0 0 0 0	100100101	000000
0 0 0 0 0	000000	000000

159201	12	11	00	0410	A	0	2309	04	05	43	24	A	A	2	1	1	
159404	5	10	04	0511	A	0	2011	07	05	41	100	A	A	2	1	1	
200015	02	00	12	1446	A	0	1306	0611	10	34	A	A	2	0	2	0	
200060	1	05	16	1447	A	0	3910	0611	06	57	A	A	2	0	3	0	
200212	14	00	05	1445	A	0	2511	0611	41	100	A	A	2	0	4	1	
200274	4	25	0519	A	0	3704	0611	04	64	A	A	2	0	4	1	1	
200416	3	05	16	1447	A	0	1610	0611	03	355	A	A	2	0	4	1	
240017	05	05	0030	A	0	2004	03	2	14	474	A	A	2	0	7	1	
240045	00	00	00	0310	A	0	4706	03	00	5	A	A	2	0	7	1	
250100	6	1	14	0402	A	0	4710	03	2	4	12	A	A	2	0	7	1
250400	27	1	0	4503	A	0	1510	07	05	01	52	A	A	2	0	4	1
300106	7	00	16	1435	A	0	1071	0611	10	107	T	A	2	0	7	1	
300213	1	05	17	0626	A	0	5201	0611	14	43	T	A	2	0	7	1	
300243	00	05	17	1475	A	0	4006	0611	17	152	T	A	2	0	8	1	
300261	24	04	14	1764	A	0	3300	0611	10	703	T	A	2	0	6	1	
300443	03	05	17	1430	A	0	4704	0611	04	147	T	A	2	0	7	1	
300604	04	10	10	1343	A	0	4603	0611	00	145	T	A	2	0	9	1	
300504	20	20	12	0441	A	0	5009	0611	16	04	T	A	2	0	3	1	
400002	11	00	07	1404	A	0	4004	0611	04	74	T	A	0	2	0	6	1
400017	20	05	11	0409	A	0	3611	0611	03	361	T	A	0	2	0	7	1
400020	25	07	10	1404	A	0	4210	0611	22	57	T	A	0	2	0	8	1
400022	1	00	07	1404	A	0	2012	0611	03	170	T	A	0	2	0	9	1

1	0	0	0	1	0	000000	000000	1	2	0	0	1	21
	0	0	0	0	0	000000	000000	1	2	0	0	1	21
	0	0	0	0		100100105	000000	1	0	0	0	1	20
	0	0	0	0	0	000000	000000	1	2	0	0	1	20
1	0	0	0	0	000	000000	000000	1	2	0	0	1	20
	0	0	2	0	0	010100221	000000	0	2	0	0	1	20
	0	0	0	0	0	100100101	000000	1	2	0	0	1	00
	0	0	1	0	0	000000	010010110	1	1	0	0	1	20
	0	0	0	0		000000	000000	0	2	0	0	1	21
1	0	0	0	0		000000	000000	0	0	0	0	1	00
	0	0	0	0	0	100100101	000000	1	0	0	0	1	00
	0	0	0	0	000	000000	000000	1	2	0	0	1	00
	0	0	0	0	0	000000	000000	1	2	0	0	1	00
	0	2	0	0	1	000000	000000	1	2	0	0	1	01
	0	0	0	0	0	100100105	000000	1	0	0	0	1	00
	0	0	0	0	0	000000	000000	1	0	0	0	1	00
	0	0	0	0		010100101	000000	1	2	0	0	1	00
	0	0	0	0	1	000000	000000	1	0	0	0	1	00
0	0	0	1	0	0	110100011	000000	1	2	0	0	1	00
	0	1	0	0	0	000000	000000	1	2	0	0	1	00
	0	0	0	0		100100101	000000	1	0	0	0	1	00
	0	0	0	0		110100101	000000	0	0	0	0	1	00
	0	0	0	0		100100101	000000	1	2	0	0	1	00
	0	0	0	0		111101215	000000	1	0	0	0	1	00
	0	0	0	0	0	100100115	010011120	1	0	0	0	1	00

1 0	0	1	2	000000	000000
0 0	0	0		1101010125	000000
0 0	0	0		110110101	000000
0 1	0	0	1	000000	000000
0 1	0	0		000000	000000
0 0	0	0		100100105	01001010u
1 0	0	0		000000	000000
0 0	0	0	0	110110011	000000
0 0	0	0	0	000000	000000
0 0	0	0	0	100100011	000000
0 0	0	0	0	000000	11011022u
0 0	0	0	0	100100111	000000
0 0	0	0	0	100100115	000000
1 0	0	0		000000	000000
0 0	0	0	0	000000	000000
1 0	0	0		110110221	000000
0 0	0	0	0	000000	000000
0 0	0	0		100100101	000000
1 1	0	0		100100101	000000
0 0	0	0		000100111	000000
0 0	0	0	0	000000	000000
1 0	0	0		100100111	000000
0 1	0	0	1	000100011	01001010u
0 0	0	0		110110111	000000
0 0	0	0	0	000000	000000

301920	19	12	13	13676	A	0	2912	6611	36	1325	1	4	2	7	1
302032	13	2	7	8119	A	0	3901	6611	27	63	1	4	2	2	2
302061	29	3	19	14358	A	0	3406	6611	31	2179	1	4	2	6	1
302062	9	8	17	13967	A	0	3809	6611	27	754	1	4	2	6	1
302083	13	3	12	8497	A	0	3609	6611	30	303	1	4	2	1	1
302033	3	4	16	4647	A	0	4303	6611	21	453	1	4	2	7	1
302107	1	10	18	14606	A	0	3711	6611	28	917	1	4	2	7	1
302110	1	5	11	9627	A	0	3904	6611	27	149	1	4	2	7	1
302196	12	3	20	4435	A	0	3911	66	9	26	431	1	4	2	7
302236	22	4	19	13566	A	0	3901	6611	24	697	1	4	2	7	1
302303	26	4	19	4105	A	0	3608	6611	24	655	1	4	2	7	1
302319	21	5	14	4642	A	0	3704	6611	23	144	1	4	2	7	1
302330	26	7	18	13435	A	0	3611	6611	23	452	1	4	2	7	1
350492	25	7	92	9536	A	0	1811	60	2	36	3056	1	4	2	2
351315	0	0	9	3465	A	0	2906	37	4		2	1	4	2	2
351545	25	2	34	13740	A	0	2804	64	7	36	259	1	4	2	6
351410	0	0	11	15010	A	0	3509	48	5	14	1964	1	4	2	7
352357	9	2	96	14792	A	0	2101	64	4	38	1720	1	4	2	3
353406	31	8	12	4610	A	0	3402	64	9	36	240	1	4	2	7
353400	7	8	2	13744	A	0	3006	64	7	34	711	1	4	2	7
353427	1	5	20	4150	A	0	3903	6010	2	111	1	4	2	7	1
354008	15	1	15	14403	A	0	3506	47	5	6	36	1	4	2	4
354173	0	0	96	7076	A	0	2602	25	7		2	1	4	2	6
354319	3	6	93	13547	A	0	1906	51	6	23	304	1	4	2	2
355715	14	11	27	4160	A	0	1905	44	7	25	506	1	4	2	2

1	0	0	0	0	110000015	000000
0	0	0	0	100100101	000000	
0	0	0	0	100100111	000000	
0	0	0	0	110110111	000000	
0	0	0	0	110110121	000000	
0	0	0	0	000000	000000	
0	0	0	0	100100115	000000	
0	0	0	0	110100115	000000	
0	0	0	0	100100101	000000	
0	0	0	0	100110015	000000	
1	0	0	0	000000	000000	
0	1	0	0	100101001	000000	
0	0	0	0	111001001	000000	
0	0	0	0	000000	000000	
0	0	0	0	110001001	000000	
0	0	0	0	100100101	000000	
0	0	0	0	100100101	000000	
0	1	0	0	000000	000000	
0	0	0	0	100100105	000000	
0	0	0	0	100100111	000000	
0	0	0	0	100100101	000000	
0	0	0	0	100100101	000000	
0	0	0	0	110110101	000000	
0	0	0	0	110110101	000000	
0	0	0	0	100100105	000000	
0	1	0	0	000000	000000	

0 0	0	2	1	000000	000000
0 1	0	0	0	000000	000000
0 0	0	0	0	100100101	000000
0 0	0	0	0	000000	000000
1 1	0	0	0	000000	000000
0 0	0	0	0	110100115	000000
0 0	0	0	0	111111221	000000
0 0	0	0	0	100100105	000000
0 1	0	0	1	100100215	000000
0 0	0	0	2	000000	000000
0 0	0	0	0	000000	000000
0 0	1	0	0	110100115	000000
1 0	1	0	0	000000	011010220
1 0	0	0	1	000000	000000
2 0	0	0	0	000000	000000
1 0	0	0	0	000000	000000
1 1	0	0	0	000000	000000
1 1	0	0	0	000000	000000
1 1	0	0	0	000000	000000
0 0	0	0	0	100110101	000000
0 1	0	0	0	000000	000000
2 0	0	0	1	110100111	000000
1 0	0	0	0	000000	000000
2 0	0	0	0	000000	000000
0 0	0	0	0	110110111	000000

750301	28	7 12	73 0	A 0	5702	57	5
150459	2	6 14	1241	0 47	4701	47	1
157222	25	10	5	003	0 57	12	4409
550484	13	2 07	15032	0 60	201	2401	63 7 35
550609	25	6 7	4326	0 55	022	2610	40 1 6
150297	25	4 16	4564	0 45	002	2509	45 1 9
150103	4	6 18	0034	0 42	002	3010	37 1 11
150104	23	5 5	4703	0 51	002	2407	17 4 1
150201	6	7 17	10826	0 44	002	4205	45 7 1
251228	4	4 11	14767	0 41	002	4510	41 7 5
450274	0	6 2	14444	0 54	002	4013	45 0 7
500311	24	5 13	4520	0 47	002	6511	65 11 3
40465	0	0 17	15031	0 45	002	2011	45 0 44
46727	27	0 12	0573	0 72	150	3604	65 11 30
501363	27	0 12	0573	0 72	150	3604	65 11 30
10144	3	0 07	14516	0 54	151	2011	40 0 4
100324	2	7 2	4320	0 71	151	2492	65 11 30
100374	24	1 5	127 8	0 73	151	2504	67 4 10
100306	24	2 4	0575	0 62	151	1704	50 4 41
150235	20	1 4	0564	0 65	151	1801	65 2 43
050423	11	10	1	0526	0 71	151	2904
150131	25	4 3	4444	0 54	150	2212	53 1 1
10024	0	0 7	4326	0 75	151	4002	65 11 30
150253	16	2 3	1	051	0 72	150	2713
401722	0	13	15	4454	0 64	154	3501
35010	0	5	1	4434	0 55	154	3403
1 2 2 2 1 1 1	12	1 1	11	05	0 55	154	3403

0	0	0	1	0	11	000000	000000
1	0	0	0	0		110100105	000000
0	1	7	0	0		000000	000000
0	0	0	0	0		110110221	000000
0	0	0	0	0		100100101	000000
0	0	0	0	0	0	000000	000000
0	0	1	0	0		110110111	000000
0	0	0	0	0		110110221	000000
0	0	0	0	0	0	100100101	000000
0	0	0	0	0		100100101	000000
1	1	0	0	0		000000	000000
0	1	0	0	0	0	110110111	000000
0	0	0	0	0		110110111	000000
1	1	0	0	7	1	000000	000000
1	1	0	0	0		000000	000000
1	1	1	0	0	0	000000	000000
0	0	0	0	0	0	100100101	000000
0	0	1	0	0		100100101	000000
0	0	0	0	0		110110221	000000
0	0	0	0	0		110110101	000000
0	0	1	0	1	0	110111221	000000
1	1	7	0	0	0	000000	000000
0	0	1	0	0	0	111111225	000000
0	0	0	1	1	7	000000	000000
1	1	0	0	0		000000	000000

352730 14 3 06 8304 0 71 154 1007 64 2 08 462 1 A 2 6 1
 253345 1 7 8 13627 0 60 157 4411 47 4 2 4 A A 2 6 1
 10191 15 6 9 8643 0 67 162 2306 66 5 39 1570 1 A 2 2 1
 12602 17 2 12 7812 0 71 162 3512 6411 32 137 1 A 2 6 1
 52009 0 0 2 4331 0 66 162 1809 66 8 45 9999 1 A 2 0 1
 100938 16 7 2 7918 0 72 162 2904 6411 27 91 A A 2 7 1
 101535 4 5 20 8728 0 69 162 4602 6411 20 196 A A 2 7 1
 157787 18 2 3 14737 0 71 162 2595 5112 26 63 A A 2 2 1
 158094 15 10 94 14633 0 64 162 3602 5311 23 54 A A 2 6 1
 35072 28 5 96 9148 0 67 162 2605 6310 25 549 1 A 2 0 2
 354093 26 5 16 14020 0 56 162 3507 55 4 15 71 1 A 2 7 1
 355494 4 5 17 8836 0 56 162 3606 53 8 17 173 1 A 2 6 1
 355747 14 11 17 4473 0 66 162 3606 58 2 21 946 1 A 2 7 1
 357491 2 10 10 14650 0 60 162 4409 60 2 16 394 1 A 2 7 1
 159427 2 7 4 7973 0 64 177 2506 66 7 38 99 A A 2 0 1
 153420 21 2 27 13388 0 68 177 2511 58 3 32 73 A A 2 6 1
 101639 6 11 7 8707 0 67 181 4539 6411 21 44 A A 2 3 1
 101101 25 2 12 11931 0 70 183 4704 6411 19 49 A A 2 6 2
 354333 15 5 31 7987 0 53 183 2310 5212 29 91 1 A 2 6 1
 450533 26 2 7 4699 0 65 193 2307 65 1 37 1738 1 A 2 7 1
 151233 2 1 6 17928 0 61 196 3502 64 7 3 25 A A 2 7 2
 200197 19 9 11 14030 0 66 197 4406 6411 22 43 A A 2 6 1
 450381 0 3 0 8745 0 54 199 2210 25 7 2 31 1 A 2 8 2
 250526 14 10 93 4602 0 64 209 2308 6411 43 99 A A 2 7 2
 100103 4 8 8 17492 0 72 204 3795 6411 24 116 A A 2 0 1

0 0	0 0 0 1	000000	000000
0 0	0 0	100100105	000000
0 0	1 0	100100101	000000
0 0	0 0	100100105	000000
0 0	0 0	100100101	000000
0 0	0 0	100100101	000000
0 1	0 1 1 0 0	100100101	010010110
0 0	0 0	110110111	000000
1 0	0 0	110110101	000000
0 0	0 0	100100105	000000
0 0	0 0 0 0	000000	000000
1 0	0 0 0 0 0 0 0	110110200	000000
0 0	0 0	000000	000000
1 0	0 0	100100105	000000
0 0	0 0 0 0	000000	000000
1 0	0 0	000000	000000
1 0	0 0	010110111	000000
1 0	0 0 0 0	110110200	000000
0 0	0 0	110110101	000000
1 0	0 0	010110215	000000
0 0	0 0 0 0 0 0	000000	011111020
0 0	0 0 0 0	100100101	010110200
0 0	0 0 0 0	010110111	000000
0 1	0 0	100100101	000000

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	8												

0 0	1	~	1	00	011111221	000000	1 2 2 0
1 0	0	0			000000	000000	1 2 2 0
0 0	1	0	01		000000	000000	1 9 2 0
1 0	1	0	0	0	100100015	000000	1 2 2 0
0 0	0	0			110110101	000000	1 2 2 0
0 0	0	0			000110011	000000	1 2 2 0
1 0	0	0			010100021	010110120	2 9 2 0
1 0	0	1	77	0	110110111	000000	2 2 2 0
1 0	0	0			100100105	000000	2 9 2 0
0 0	0	1	77		000000	000000	2 2 2 0
0 0	0	0			111111221	000000	1 2 2 0
1 0	0	0			000000	000000	1 2 2 0
0 1	0	0	7		000000	000000	1 2 2 0
0 0	0	0			110110101	000000	1 2 2 0
1 0	0	0	0		000000	000000	1 9 2 0
0 0	0	0	0		000000	000000	2 9 2 0
1 0	0	0			000000	000000	1 2 2 0
0 0	0	0			110110225	000000	1 9 2 0
0 0	0	0	0	0	110100115	000101000	1 9 2 0
0 0	0	0	1	0	100100101	000000	1 2 2 0
1 0	2	0	1	0	110110111	000000	2 9 2 0
0 0	0	0			110110215	000000	1 2 2 0
0 0	0	0	0	0	100110111	000000	1 2 2 0
0 0	0	0			110110101	000000	1 9 2 0
1 0	0	0			000000	000000	2 2 2 0

154753	24	7	3	4174	0	55	423	4112	64	2	22
154754	14	12	11	14624	0	55	423	4008	54	10	22
200076	10	12	11	0243	0	74	420	4409	64	11	22
252371	20	5	7	13415	0	41	420	2407	61	2	16
400155	14	5	11	12037	0	71	420	2535	61	11	41
700411	12	2	7	7348	0	66	420	2602	64	11	22
151431	16	4	10	15010	0	67	420	3734	54	11	20
301662	27	2	3	13755	0	74	423	2511	64	11	41
302206	21	5	13	13032	0	74	420	3113	64	11	41
352163	27	6	27	4070	0	58	420	2211	55	0	14
45210	0	0	55	002	0	66	420	2010	20	2	1
353127	4	4	6	4464	0	43	420	2606	60	2	20
351511	14	5	10	14423	0	65	420	2704	55	6	24
351934	17	10	31	4234	0	71	420	2405	72	5	2
354424	1	6	10	1354	0	65	420	2504	65	10	24
354664	15	4	22	14422	0	65	420	1934	54	1	14
755004	11	5	11	14421	0	62	420	2032	55	3	14
355004	11	5	11	14421	0	62	420	2032	55	3	14
357445	20	7	7	14635	0	61	420	2034	55	3	14
754719	24	7	7	14270	0	67	423	4137	62	3	24
450074	7	4	10	1414	0	61	420	1909	51	5	30
430304	14	2	17	14421	0	62	420	2604	64	1	14
500044	7	1	20	15010	0	67	420	4510	64	1	14
154120	12	10	15	4124	0	55	420	2904	62	1	14
351151	15	0	12	1463	0	60	420	1201	54	2	14

1 1 0	0 0	000000	000000	1
1 0 0	0 1 0	100100105	000000	1
0 0	0 0	100100101	000000	1
1 0	0 0	000000	000000	1
1 0 0	0 0 0	000000	000000	1
0 0	1 1	100100101	000000	1
0 0	0 0	110110111	000000	1
0 0	0 0	110110101	000000	1

3561 7 14 0 15 46 72 0 23 23 51 10 1 3 10
 153474 13 0 2 13474 0 51 12 2507 48 0 23
 100475 2 0 2 4426 0 72 0 31 3600 10411 25
 154412 3 10 14 2440 0 72 0 25 3610 4410 10
 50523 10 11 14 14724 0 59 423 4702 34 7 1
 150945 26 14 10 4444 0 54 420 4504 37 1 7
 154946 10 12 16 13727 0 57 420 4306 37 5 13
 350413 11 0 20 4502 0 52 0 76 4308 35 0 2
 414 1 4 2 7
 213 4 4 2 3
 54 4 4 2 4
 474 4 4 2 4
 20 1 4 2 7
 142 4 4 2 7
 103 1 4 2 7
 4 4 4 2 7

COHORT "B"

Reader 5

"Normals"

pp. 283 - 303

"Less-than-normals"

pp. 304 - 314

[illegible]

15 16 11 20 12917 A 0	4808 57 6 14	53 A 5 1 7 1
31 3 4 18 10676 A 0	3411 4613 11	392 A 5 1 7 1
33 12 7 8 15453 A 0	2606 60 2 37	619 A 5 1 6 1
63 9 5 12 7615 A 0	4209 6611 21	195 T 5 1 2 1
10462 5 4 17 10501 A 0	4510 6611 23	152 T 5 1 7 1
10513 12 4 19 11501 A 0	4507 6611 20	57 T 5 1 5 1
10747 11 2 19 15293 A 0	4509 6611 20	122 T 5 1 7 2
40161 0 0 3 10576 A 0	1705 63 6 43	146 T 5 1 2 1
50039 14 11 20 7608 A 0	4801 49 1	2 T 5 1 4 1
50477 6 11 18 5295 A 0	4703 50 1 2	20 T 5 1 7 1
50565 0 0 13 5027 A 0	3311 59 2 5	984 T 5 1 6 1
50515 11 4 19 12462 A 0	4801 58 4 8	65 T 5 1 2 1
50643 1 11 7 7745 A 0	4709 47 4	52 T 5 1 7 1
50656 14 4 19 15763 A 0	4510 47 5 1	19 T 5 1 9 1
50715 0 0 1 7643 A 0	2006 46 4 2	34 T 5 1 9 2
50767 29 8 29 11624 A 0	3732 46 7 3	243 T 5 1 7 1
90006 27 5 14 4034 A 0	4005 4611 25	199 T 5 1 9 2
90074 0 0 20 11561 A 0	3702 4611 18	59 T 5 1 7 1
90347 0 0 4 15239 A 0	2602 4611 13	147 T 5 1 9 2
90372 3 3 8 13422 A 0	2306 4611 10	263 T 5 1 6 1
90134 0 0 11 10406 A 0	2908 4611 3	16 T 5 1 9 2
90114 21 3 18 10597 A 0	5804 4611 8	42 T 5 1 9 1
40177 0 3 0 15558 A 0	1811 43 6 36	213 T 5 1 9 1
40140 6 5 2 7444 A 0	2432 44 2 19	61 A 5 1 7 3
80170 0 0 19 11913 A 0	3702 4611 28	246 T 5 1 7 1

0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000-0	000000-0	1 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
1 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000-0	000000-0	1 0
0 0 0 0	000000-0	000000-0	1 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
1 0 0 0	000000	000000	1 0
0 0 0 0	000000	000000	0 0
0 0 0 0	000000	000000	1 0

90177 22	7 19 10695 A	0	3708 6611 25	303 T 5 1
80196 0	0 2 4771 A	0	1902 6611 29	248 T 5 1
80217 0	0 96 7196 A	0	1811 66 5 23	180 T 5 1
80219 2	4 10 10900 A	0	2704 41 0 1	8 A 5 1
80227 22	9 11 15213 A	0	2901 6611 22	47 T 5 1
80247 0	0 11 10499 A	0	2910 6611 19	459 T 5 1
80248 0	0 97 15151 A	0	1901 6611 2	407 T 5 1
80306 29	11 9 7534 A	0	4310 65 5	10 A 5 1
80513 4	2 10 15413 A	0	4707 6611 19	123 T 5 1
100022 6	6 13 11636 A	0	3607 6611 20	642 A 5 1
100015 19	9 16 5141 A	0	1606 6611 10	102 A 5 1
100053 17	7 16 7543 A	0	3302 6611 31	443 A 5 1
100043 11	12 14 11576 A	0	4110 6611 25	113 A 5 1
100027 24	2 16 11608 A	0	3403 6611 32	443 A 5 1
100096 20	12 15 15397 A	0	3309 6611 29	534 A 5 1
100134 11	2 12 15323 A	0	3704 6611 28	171 A 5 1
100147 17	0 12 3766 A	0	2803 6611 34	764 A 5 1
100159 19	4 15 10412 A	0	3302 6611 33	569 A 5 1
100170 23	5 16 10471 A	0	3612 6611 27	155 A 5 1
100210 1	12 15 11956 A	0	5105 6611 15	13 A 5 1
100211 9	10 8 5071 A	0	2505 6611 19	74 A 5 1
100239 9	5 20 4708 A	0	4505 6611 19	93 A 5 1
100269 19	2 16 10422 A	0	3509 6611 21	147 A 5 1
100271 15	1 11 15342 A	0	4008 6611 29	23 A 5 1
100304 29	6 17 15243 A	0	5105 6611 11	23 A 5 1

	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	2	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	2	0
	0	0	0	0	000000-0	000000-0	1	0
	0	0	0	0	000000	000000	2	0
I	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000-0	000000-0	1	0
	0	0	0	0	000000	000000	2	0
	0	0	0	0	000000	000000	2	0
	0	0	0	0	000000	000000	2	0
I	0	0	0	0	000000-0	000000-0	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	2	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0
	0	0	0	0	000000	000000	1	0

[illegible]

150733	13	1	11	11014	A	0
150170	21	13	16	13047	A	0
150146	27	6	3	511	A	0
150135	2	9	10	13040	A	0
150209	24	5	4	511	A	0
101226	9	6	13	11217	A	0
101227	21	13	23	15104	A	0
101224	14	1	11	11275	A	0
101211	4	3	15	11405	A	0
101205	21	9	5	15631	A	0
101563	14	13	15	15055	A	0
101540	8	5	12	5143	A	0
101560	25	10	14	11402	A	0
101490	19	13	3	11407	A	0
101437	5	1	2	2006	A	0
101401	13	11	3	13044	A	0
101453	5	11	14	2741	A	0
101403	1	12	14	11943	A	0
101301	25	7	19	9356	A	0
101339	6	13	4	11625	A	0
101127	4	2	14	2704	A	0
101101	5	7	4	2433	A	0
101115	23	13	10	2704	A	0
101091	24	4	15	2403	A	0
101247	4	12	4003	A	0	
4505	6011	11				
4504	6011	27				
4507	6011	33				
4011	6011	4				
4709	6011	13				
4001	6011	19				
5104	6011	11				
4705	6011	19				
4210	6011	23				
4503	6011	20				
2510	6011	43				
3606	6011	27				
5712	6011	4				
4707	6011	24				
4907	6011	17				
4500	6011	31				
4708	6011	13				
4905	6011	11				
4934	6011	17				
5412	6011	1				
4407	6011	1				
5007	6011	5				
4507	6011	15				
4907	6011	1				

[illegible]

150239	16	1	1411914	A	0	4907	50	0	1	A	5	1	
150179	23	13	1613457	A	0	4507	61	2	15	74	A	5	1
150145	27	6	91119	A	0	5007	51	5		1	A	5	1
150109	2	9	1919940	A	0	4407	46	5	1	A	5	1	
150069	23	5	45111	A	0	4612	47	1		A	5	1	
101736	9	6	1811747	A	0	4904	6611	17	122	A	5	1	
101727	21	10	2018164	A	0	4805	6611	19	52	A	5	1	
101724	14	1	111735	A	0	4708	6611	19	173	A	5	1	
101711	4	9	1611495	A	0	4509	6611	21	118	A	5	1	
101705	21	9	615631	A	0	4907	6611	17	9	A	5	1	
101660	14	12	1615635	A	0	3707	6611	29	765	A	5	1	
101640	8	6	5149	A	0	5712	6611	8	7	A	5	1	
101569	25	10	1411492	A	0	3608	6611	26	441	A	5	1	
101499	18	10	811497	A	0	2510	6611	40	236	A	5	1	
101493	6	3	87696	A	0	2603	6611	37	130	A	5	1	
101463	19	11	913494	A	0	4503	6611	20	74	A	5	1	
101453	5	11	14741	A	0	4210	6611	23	108	A	5	1	
101403	9	12	1411937	A	0	4705	6611	19	23	A	5	1	
101391	25	3	1915056	A	0	5104	6611	11	23	A	5	1	
101339	6	10	811625	A	0	3001	6611	19	10	A	5	1	
101322	4	7	147398	A	0	4709	6611	19	42	A	5	1	
101321	5	7	7492	A	0	4011	6611	24	68	A	5	1	
101416	30	10	7398	A	0	3507	6611	10	272	A	5	1	
101293	23	18	7600	A	0	3508	6611	27	252	A	5	1	
101246	4	12	4997	A	0	4505	6611	21	88	A	5	1	

0 0	0 0	000000	000000	1 0
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 4
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	2 4
0 0	0 0	000000-0	000000-0	1 0
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	2 4
0 0	0 0	000000-0	000000-0	1 2
0 0	0 0	000000-0	000000-0	1 4
0 0	0 0	000000	000000	1 0
0 0	0 0	000000	000000	2 4
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	1 4
0 0	0 0	000000-0	000000-0	1 0
0 0	0 0	000000	000000	1 0
0 0	0 0	000000-0	000000-0	1 2
0 0	0 0	000000	000000	1 2
0 0	0 0	000000	000000	2 4

152334	12	5	1	15211	A	0	3513	47	9	11	75	A	5	1
152414	6	4	23	15436	A	0	5205	54	5	6	13	A	5	1
152414	21	4	20	2653	A	0	3704	43	7	5	44	A	5	1
152427	0	3	31	10553	A	0	2209	201			2	A	5	1
152426	5	0	2	15533	A	0	4739	4211			A	5	1	
152445	1	1	13	2505	A	0	2404	54	7	55	483	A	5	1
152444	4	0	10	5035	A	0	3705	34	7	4	17	A	5	1
152449	25	5	17	10409	A	0	4104	46	3	4	13	A	5	1
152445	4	0	15	5124	A	0	3720	55	3	14	41	A	5	1
152422	13	7	16	11936	A	0	2010	55	9	12	77	A	5	1
152370	5	0	23	10437	A	0	4704	47	9		13	A	5	1
152333	20	3	16	11503	A	0	3504	3710	12	12	126	A	5	1
151304	7	11	0	2630	A	0	2504	49	5	2	153	A	5	1
151304	13	13	10	10347	A	0	4205	45	9	4	9	A	5	1
151405	13	3	11	5107	A	0	4507	46	7	1	6	A	5	1
151724	1	5	14	11454	A	0	4704	47	5		A	5	1	
151756	30	13	13	15303	A	0	4510	4410	7		7	A	5	1
151904	13	4	19	12440	A	0	4107	53	3	3	91	A	5	1
151440	3	7	13	15537	A	0	3607	40	9	4	3	A	5	1
151450	14	1	3	2101	A	0	4501	47	2	2	6	A	5	1
152004	24	12	17	5733	A	0	5310	54	3	4	4	A	5	1
152013	27	3	7	5133	A	0	2603	47	7	13	654	A	5	1
152025	17	4	17	4454	A	0	2402	47	5	15	390	A	5	1
152400	22	13	19	15404	A	0	4630	54	9	5	12	A	5	1
152429	3	10	17	10445	A	0	4004	47	0		117	A	5	1

[illegible]

152749 24	A 13 2534 A	4230 41 4	A A 5 1 1	1
152745 14	13 15 11437 A	4608 34 11	3 A 5 1 1	1
152001 14	4 17 10374 A	4511 41 5 2	6 A 5 1 1	1
154107 13	2 9 11571 A	3705 41 2 14	36 A 5 1 1	1
151141 21	5 243 A	2508 44 2 2	55 A 5 1 1	2
154306 13	13 17 7 11650 A	2505 57 2 32	1401 A 5 1 1	1
154304 13	13 17 10433 A	4704 44 2 1	33 A 5 1 1	1
153741 13	7 13 10740 A	4704 40 7	A 5 1 1	1
154521 24	2 4 11475 A	3611 43 11 4	13 A 5 1 1	1
154536 6	4 4 15347 A	4702 43 0	A A 5 1 1	1
154541 17	A 13 2339 A	4702 47 5	A 5 1 1	1
153415 23	1 2 13336 A	4704 43 2	A 5 1 1	1
153741 3	5 21 721 A	3434 56 7 17	20 A 5 1 1	1
154024 14	1 3 4747 A	4710 44 1	A 5 1 1	1
154023 23	1 7 10334 A	3703 46 5 3	3 A 5 1 1	2
154127 2	10 12 1103 A	4404 46 0 2	14 A 5 1 1	1
154174 3	5 15 11431 A	4406 42 0	2 A 5 1 1	1
154330 26	1 14 4747 A	4704 52 7 12	11 A 5 1 1	1
154421 7	5 12 15327 A	4613 47 11 13	407 A 5 1 1	1
154445 24	1 5 5135 A	4412 55 4 11 3	2 A 5 1 1	1
154550 20	13 13 79 A	4407 51 10 3	1 A 5 1 1	1
154554 4	2 26 15337 A	4704 54 5 11	33 A 5 1 1	1
154721 15	11 11 15437 A	3411 40 10 4	14 A 5 1 1	1
154847 11	5 16 4474 A	3413 41 8 12	32 A 5 1 1	1
154480 7	5 4 4743 A	4104 44 7 3	4 A 5 1 1	1

3	r	c	r	cccccc	cccccc
3	7	c	0	cccccc	cccccc
c	c	c	c	cccccc	cccccc
c	c	c	c	cccccc-0	cccccc-0
c	r	c	0	cccccc	cccccc
c	c	c	c	cccccc	cccccc
0	0	0	c	cccccc-c	cccccc-c
c	c	c	0	cccccc	cccccc
3	c	0	c	cccccc	cccccc
0	c	c	c	cccccc	cccccc
0	0	0	c	cccccc-c	cccccc-0
c	c	c	c	cccccc	cccccc
3	c	0	c	cccccc	cccccc
0	c	c	c	cccccc	cccccc
0	0	0	c	cccccc-c	cccccc-0
c	c	c	c	cccccc	cccccc
3	0	c	c	cccccc	cccccc
0	0	c	c	cccccc-c	cccccc-0
0	0	0	c	cccccc	cccccc
0	c	c	c	cccccc	cccccc
0	0	c	c	cccccc	cccccc
0	0	c	c	cccccc	cccccc
3	0	0	c	cccccc	cccccc
0	c	c	c	cccccc	cccccc
0	0	0	c	cccccc	cccccc
c	c	c	c	cccccc	cccccc
0	c	c	0	cccccc-0	cccccc-0
0	c	c	c	cccccc	cccccc
0	0	c	c	cccccc	cccccc

[illegible]

[illegible]

159340 22	1	11	11650	A	0	4990 45 6 15	26	A	5	1
159344 19	2	20	10794	A	0	4802 51 2 3	6	A	5	1
159331 19	2	20	11542	A	0	2011 64 3 21	41	A	5	1
159327 9	6	10	10779	A	0	2906 41 0 12	9	A	5	1
159322 27	5	0	11771	A	0	4208 69 6 21	182	A	5	1
159326 6	4	6	10523	A	0	2607 48 3 17	58	A	5	1
159330 9	10	36	5100	A	0	1512 6110 27	27	A	5	1
159306 14	11	0	15357	A	0	2007 5210 74	491	A	5	1
159324 25	7	15	15315	A	0	1308 38 6 4	7	A	5	1
159335 27	10	0	5226	A	0	4608 6411 16	93	A	5	1
200030 2	8	17	11527	A	0	3511 6611 31	293	A	5	1
200037 23	12	4	15157	A	0	3704 6611 29	29	A	5	1
200127 20	12	14	13719	A	0	3405 6611 26	206	A	5	1
200169 16	11	20	11539	A	0	4603 6611 20	55	A	5	1
200134 30	4	2	10571	A	0	2509 6611 41	105	A	5	1
200230 15	3	15	5149	A	0	4301 6611 20	42	A	5	1
200403 24	11	10	10764	A	0	4608 6611 17	47	A	5	1
250036 22	3	18	15627	A	0	4208 47 3	1	A	5	1
250071 1	10	5	10613	A	0	2502 42 7 7	14	A	5	1
250714 16	6	18	7560	A	0	3703 47 6 10	72	A	5	1
250347 1	5	16	4445	A	0	3512 47 6 7	10	A	5	1
250396 9	3	19	15150	A	0	4509 46 5	5	A	5	1
250446 14	5	12	15374	A	0	4503 46 6	2	A	5	1
250470 23	5	19	15201	A	0	4504 45 6	1	A	5	1
250472 9	7	15	5137	A	0	4501 49 6 7	2	A	5	1

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

0 0	0 0	000000	000000
1 0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000	000000
0 0	0 0	000000-0	000000-0

159127 7 2 134770 0 0 1 17 2001 201
 101 12 8 7 11667 0 0 1 1 2001 201
 51067 17 7 20 1170 0 0 1 1 1 17
 40761 0 3 0 7500 0 21 1 1 274 0 11 26
 151566 16 5 26 4711 0 05 151 207 0 8 37
 155007 10 1 0 15645 0 21 161 6110 0 0
 156704 10 6 0 7741 0 05 101 4104 0 7 20
 157202 4 7 21 11700 0 07 161 1105 6110 25
 200151 26 11 0 7747 0 26 101 0705 6711 23
 359270 1 11 0 7745 0 07 171 5607 54 5
 653016 13 5 11 0517 0 04 1 0405 0 4 29
 152204 24 5 11 10500 0 07 151 4010 42 6 1
 158440 6 11 0 11957 0 07 153 1011 6512 42
 251130 24 7 0 11744 0 04 155 4509 45 1
 40117 0 0 0 4530 0 05 157 2002 0 8 6 10
 156429 0 0 7 15534 0 46 157 4207 5111 1
 40764 0 11 0 15264 0 09 162 2404 47 1 15
 150569 21 4 13 4940 0 23 162 2011 42 7 13
 155500 10 0 16 10916 0 45 162 4006 5311 17
 155546 4 7 12 15144 0 23 162 2007 47 1 17
 157100 30 5 7 0170 0 06 162 2505 4711 12
 154143 10 0 1 4027 0 21 162 3406 4613 10
 252247 4 10 0 10522 0 26 164 4605 44 5
 100576 11 5 0 4957 0 22 162 2006 5111 23
 150560 11 4 0 4200 0 25 164 2406 45 5 15
 32 4 5 1 7 1

[illegible]

154940 0 0 00 7477 0 70 127 1004 4311 21
 750311 27 12 14 4770 0 64 163 6001 44 5 4
 101107 28 2 7 15475 0 73 191 4211 6011 32
 100401 22 5 19 15466 0 68 193 6624 6011 20
 450525 10 0 11 11477 0 62 153 4901 4010
 610757 7 4 0 917 0 52 109 4010 4010 0
 152147 14 0 17 7310 0 75 201 4103 45 1 7
 154217 13 0 20 4957 0 61 241 4906 45 7
 100355 40 0 11 10616 0 70 260 3409 6011 35
 100400 26 1 12 11744 0 73 260 4410 6011 30
 354724 30 0 00 7473 0 70 340 4701 44 2
 101501 10 0 1 10701 0 73 267 4412 6011 24
 355472 0 0 0 7405 0 55 322 2103 3610 11
 100464 17 1 14 10508 0 71 231 4704 6011 10
 301074 7 4 11 5181 0 70 341 4604 6011 20
 301004 5 0 0 11674 0 75 231 2305 6011 17
 251462 20 2 00 7624 0 56 374 4703 4111 4
 155044 27 2 20 4947 0 60 443 2704 40 1 10
 150246 30 11 0 15632 0 71 410 4011 6012 10
 44 4 12 0 15775 0 57 403 2502 41 1 11
 95 1 7 2 4140 0 47 430 3004 44 7 17
 10014 13 0 16 11493 0 71 420 4804 4411 17
 10014 13 0 16 11493 0 71 420 4804 4411 17
 10033 15 1 14 10571 0 72 423 4604 6011 21
 100472 24 1 11 13057 0 70 430 4410 6011 13
 50124 4 1 1 15817 0 67 420 4604 6011 11

[illegible]

5049 11 10 17 1060 0 65 40 0 007 471 1
 40756 7 1 47 4 0 64 60 000 0 1
 40707 11 0 06 1100 0 74 40 0 007 471 1
 100707 0 11 12 4012 0 74 40 1300 601 00
 101266 07 7 10 1161 0 72 40 0 001 00
 101667 4 7 15 10512 0 75 40 0 000 001 17
 150163 4 1 7 731 0 65 40 0 001 45 1
 150574 0 1 7 1157 0 65 40 0 007 43 11
 152606 10 7 1 10527 0 65 40 0 000 47 11
 154758 12 11 12 11421 0 72 40 0 010 00 4
 154776 1 0 0 750 0 72 40 0 000 46 8
 155158 23 7 06 15613 0 67 40 1701 67 0 47
 155741 7 5 12 4747 0 66 420 4900 41 7
 155906 24 6 6 10566 0 64 40 0 001 44 15
 156048 4 1 0 10662 0 72 40 0 4400 47 5 8
 156720 07 4 16 4052 0 72 40 4700 41 0 8
 156730 11 0 1 11527 0 61 40 0 100 41 0 00
 157542 10 5 07 15111 0 61 40 0 1011 27 7 2
 157545 33 11 06 18150 0 60 420 2210 06 1
 159001 21 12 06 1061 0 60 420 1710 40 4 06
 159346 36 7 0 7474 0 65 420 4410 43 1 10
 200070 25 2 12 15400 0 75 400 4302 001 20
 251136 25 10 0 15558 0 65 420 2511 41 6 8
 300057 22 7 0 51446 0 71 400 4200 0 11 04
 300545 11 0 17 4512 0 70 420 0010 0011 06

[illegible]

351397 0 0 02 1 3747 0 54 420 2409 54 4 24 1312 1 5 1 6 1
 352491 25 0 54 7549 0 56 420 2506 50 11 41 4222 1 5 1 6 1
 352491 0 4 12 7541 0 75 422 4704 47 7 155 1 5 1 7 2
 35413 12 4 4 7412 0 54 422 2602 54 13 22 1155 1 5 1 7 2
 355157 3 0 12 4761 0 65 422 2705 44 6 455 1 5 1 7 1
 357202 0 0 1 10730 0 41 422 1000 63 4 12 155 1 5 1 7 1
 357613 4 4 34 7540 0 41 422 3304 74 11 39 1 5 1 6 1
 403143 2 2 2 7514 0 72 422 3904 56 11 27 77 1 5 1 7 1
 403143 2 4 17 7506 0 51 422 3611 47 5 210 4 5 1 6 2
 400465 23 11 12 13545 0 72 424 4409 64 13 21 45 4 5 1 4 3
 755124 13 4 34 13547 0 50 434 4701 56 7 12 674 1 5 1 2 1
 352164 24 0 44 7424 0 71 441 1911 64 7 34 62 1 5 1 2 1
 0927 27 4 14 11706 0 73 447 4705 64 11 27 1046 1 5 1 7 1
 154126 14 5 41 11544 0 52 441 4806 63 2 0 149 4 5 1 2 1
 53374 0 3 10 15447 0 74 441 4406 56 12 13 121 1 5 1 4 1
 250471 21 0 11 4701 0 63 451 4405 63 2 13 5 4 5 1 1 1
 752494 23 17 17 4324 0 53 453 7406 47 2 1 76 1 5 1 2 1
 251494 2 2 12 4124 0 71 451 4524 45 0 2 4 4 1 1 1
 357613 1 13 1 13547 0 72 537 1000 44 1 4 5 1 4 1 1
 359411 25 5 35 7224 0 54 173 1004 54 1 31 25 1 4 1 6 1
 10130 3 0 17 4735 0 75 541 7702 64 11 4 151 1 5 1 7 1
 154749 21 0 1 10649 0 76 541 7912 65 4 13 33 4 5 1 2 2
 357427 19 1 57 13271 0 44 541 1501 44 4 0 212 1 5 1 2 1
 154532 17 2 14 7750 0 41 541 3511 74 12 4 5 1 2 1
 151164 24 12 44 4402 0 41 541 3411 74 12 4 5 1 2 1

[illegible]

0 0	0	0	000000	000000
0 0	0	0	000000	000000
0 0	0	0	000000	000000

750203 07 12 15	2210 L 56	6430 00 7 1	3 1 8 1 9 1
750404 7 5 13	11537 L 56	5405 56 6 3	1 7 5 1 9 1
750405 21 4 10	7342 L 57	5208 57 6 5	2 1 5 1 9 2

0 0	0 0	110110015	000 70
0 0	0 0	100110101	000000*
0 0	0 1	000000	000000
1 0	0 0	000000	000000
1 0	0 0	000000	000000
1 0	0 0	110100101	000000
0 0	0 0	100100011	000000
0 0	0 0	110110101	000000
0 0	0 0	100100101	000000
0 0	0 0	000000	000000
0 0	0 0	110111101	000000
0 1	0 0	111111011	000000
1 1	0 0	000000	000000
0 0	0 0	110111101	000000
0 0	0 0	110110101	000000
0 1	0 0	110100111	000000
0 0	0 0	111111011	000000
0 0	0 0	100110101	000000
1 1	1 1	000000	000000
1 1	0 0	000000	000000
1 0	0 0	000000	000000
0 0	1 0	100100011	000000
1 1	1 1	100110111	000000
1 0	0 0	100110101	000000
1 1	0 0	110110101	000000

100449	13	5	13	10323	A
100450	0	5	0	513	A
100451	10	0	14	11047	A
100452	10	4	15	10470	A
100453	1	7	14	7477	A
100454	4	4	0	15437	A
4051	2	0	0	11447	A
4052	17	0	0	15441	A
4053	17	0	10	15420	A
4054	0	0	2	15500	A
4055	0	0	7	11077	A
4056	0	0	1	4000	A
4057	1	2	0	5410	A
50770	0	0	0	11792	A
50771	10	12	16	10457	A
50772	11	1	10	13437	A
40047	14	10	0	13430	A
10047	01	7	11	15261	A
10048	14	0	0	4000	A
10049	10	7	10	11067	A
10050	10	12	0	12560	A
210	0	0	1	10470	A
234	1	1	2	11275	A
235	13	10	17	13401	A
400	1	0	0	10477	A
1007	6411	11	17	15	271
2004	6411	20	14	15	271
2704	6411	36	09	15	271
1707	6411	13	76	15	271
2710	6411	02	15	15	271
3006	6411	01	42	15	271
5202	6411	14	10	15	271
2304	6411	13	10	15	271
1012	6411	17	04	15	271
4402	6411	15	04	15	271
2511	6411	15	04	15	271
2507	6411	15	04	15	271
2302	6411	15	04	15	271
0807	6411	11	04	15	271
1402	6411	11	04	15	271
2725	6411	20	04	15	271
2701	6411	20	04	15	271
2504	6411	20	04	15	271
3007	6411	21	04	15	271
4110	6411	11	04	15	271
1507	6411	21	04	15	271
2402	6411	11	04	15	271
4204	6411	20	04	15	271

0 0	0	0		10011011	000000
1 1 0	0	0		000000	000000
1 1 0	0	0		11011010	000000
1 1 0	0	0		000000	000000
1 1 0	0	0		000000	000000
0 0	0	0		11011011	000000
1 1 0	0	0		11011011	000000
0 0	0	0		11011011	000000
0 0	0	0		11011011	000000
0 0	0	0	7	11011011	000000
1 1 0	0	0		000000	000000
1 0	0	0		10011011	000000
1 1 0	0	0		000000	000000
1 1 0	0	0		000000	000000
1 0 0	0	0		11011011	000000
1 0 0	0	0		10011011	000000
0 0	0	0		11010010	000000
0 0	0	0		000000	000000
1 1 0	0	0		000000	000000
0 0	0	0		10011011	000000
1 1 0	0	0		000000	000000
0 0	0	0		10011011	000000
0 0	0	0	7	10010011	000000
0 0	0	0		000000	000000
0 0	0	0		10011011	000000

1 0 0	0 0 0	10010101 000000	1 0 0 0 1 0 0
0 0	0 0	10010010 000000	1 0 0 0 1 0 1
0 0	0 1 11	11011011 000000	1 0 0 0 1 0 1
0 0	0 0	11011010 000000	1 0 0 0 1 0 1
0 1 1 1 1 0	1 1 1 1	000000 000000	1 0 0 0 1 0 1
0 0	0 0	10010010 000000	1 0 0 0 1 0 1
1 1 0	0 0	000000 000000	1 0 0 0 1 0 1
1 1 0	0 0	000000 000000	1 0 0 0 1 0 1
0 1	1 0 0	01011001 000000	1 0 0 0 1 0 1
0 0	0 0	01111111 01111110	1 0 0 0 1 0 1
0 0	0 0	10011011 000000	1 0 0 0 1 0 1
1 0 0	0 0 0 1	10010010 000000	1 0 0 0 1 0 1
1 1 0	0 0	000000 000000	1 0 0 0 1 0 1
1 0	0 0	000000 000000	1 0 0 0 1 0 1
0 0	0 1	10011010 000000	1 0 0 0 1 0 1
0 0	0 1 0	000000 00011010	1 0 0 0 1 0 1
1 1 0	0 0	10111101 000000	1 0 0 0 1 0 1
1 1 0	0 0	11010010 000000	1 0 0 0 1 0 1
0 0	0 0	10011010 000000	1 0 0 0 1 0 1
1 1 0	0 0	000000 000000	1 0 0 0 1 0 1
0 0	0 0	000000 000000	1 0 0 0 1 0 1
0 0	0 0	10010010 000000	1 0 0 0 1 0 1
1 0	0 0	000000 000000	1 0 0 0 1 0 1
1 0 0	0 0	10011010 000000	1 0 0 0 1 0 1
1 1 0	0 0	000000 000000	1 0 0 0 1 0 1

0 0	0	1 11	000000	000000
0 0	0	0	11011010	000000
1 1 0	0	0	000000	000000
1 1 0	0	0	000000	000000
0 0	0	0	10011110	000000
0 0	0	0	01011110	000000
0 0	0	1 11	000000	000000
0 0	0	0 7	10011010	000000
0 0	0	1 11	10010011	000000
0 0	0	1 111	000000	000000
0 0 111	0	7 0	000000	000000
0 0	0	0	10011001	000000
0 0	0	0	11011001	000000
1 1 0	0	0	000000	000000
1 1 0	0	0	11011010	000000
0 0	0	0	11011011	000000
0 0	1 7	1 77	11000010	000000
0 111	0	0	11011010	000000
0 0	0	0	10011010	000000
1 1 0	0	1 17	000000	000000
1 0 0	0	0	000000	000000
0 0	0	0	10011010	000000
0 0	0	0	110100100	000000
0 0	0	0	10011010	000000
0 0	0	0	11011010	000000

0 0	0 0	100110101 000000
1 0 0	0 0	100110101 000000
0 0	0 0	100110101 000000
0 0	1 1 1 1	110110101 000000
1 0	0 0	100110101 000000
1 1 0	0 0	000000 000000
0 0	0 0	110110011 000000
0 0	0 0	000000 000000
1 1 0	0 0	000000 000000
0 0	0 0	000000 01111010
0 0	1 0 0 1	110111111 000000
0 0 0 0	0 0 0	010111111 000000
1 0 0	0 0 0	000000 000000
0 0	0 0	110100100 000000
1 0 0	0 0	000000 000000
0 0	0 0	100100101 000000
0 0	0 0	110110011 000000
0 0	0 0	000000 11011010
0 0	0 1 1 1	110110101 000000
0 0	0 0	100110101 000000
0 1 0 0	0 0	110110011 000000
0 1 0 0	0 0	000000 000000
0 0	0 0	100110101 000000
0 0	1 0	110110101 000000
0 0	0 0	110110101 000000

1 0 0 0 0	1101100000000000	1 0 0 0 0 0 0 0 0
1 1 0 0 1 1 1 1	000000 000000	1 0 0 0 0 0 0 0 0
1 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
0 0 0 1 1	1001000000000000	1 0 0 0 0 0 0 0 0
1 1 1 1 0 0	1001000100000000	1 0 0 0 0 0 0 0 0
0 0 0 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
0 0 0 0	1101101000000000	1 0 0 0 0 0 0 0 0
0 0 0 0	1101111010000000	1 0 0 0 0 0 0 0 0
1 1 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
1 1 1 0 0 1 1	000000 000000	1 0 0 0 0 0 0 0 0
1 0 0 0	1101110100000000	1 0 0 0 0 0 0 0 0
0 0 0 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0	1000001000000000	1 0 0 0 0 0 0 0 0
0 0 0 0	0111001000000000	1 0 0 0 0 0 0 0 0
0 0 0 0 0 0	1101100100000000	1 0 0 0 0 0 0 0 0
1 0 0 0 0	11011000100110100	1 0 0 0 0 0 0 0 0
1 1 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
1 1 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
1 1 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0	1101110100000000	1 0 0 0 0 0 0 0 0
0 0 0 0 0 0	0101110100000000	1 0 0 0 0 0 0 0 0
0 0 0 0 0 0	1010101000000000	1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0	1101101000000000	1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0	1101101000000000	1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0	000000 000000	1 0 0 0 0 0 0 0 0

0	0	0	100110011	0000000	1	2	5
0	0	0	110110111	0000000	1	2	5
0	0	0	110110101	011111100	1	2	5
0	0	0	110110101	0000000	1	2	5
0	0	0	100110101	0000000	1	2	5
0	0	0	100110101	0000000	1	2	5
0	0	0	110110101	0000000	2	2	5
0	0	0	110110101	0000000	2	2	5
0	0	0	0000000	0000000	1	2	5
1	0	0	0000000	0000000	1	2	5
0	1	0	000110101	0000000	1	2	5
1	0	0	0000000	0000000	2	2	5
0	1	0	110110101	0000000	1	2	5
0	1	0	0000000	0000000	2	2	5
0	1	0	110110101	0000000	1	2	5
0	0	0	0000000	0000000	1	2	5
1	1	0	0000000	0000000	1	2	5
1	0	0	100000101	0000000	1	2	5
1	0	0	0000000-0	0000000-0	1	2	5
0	1	0	0000000	0000000	1	2	5
0	0	0	001110011	0000000	1	2	5
0	0	0	110110101	0000000	1	2	5
1	0	0	0000000	0000000	1	2	5
1	0	0	001110101	0000000	2	2	5
0	0	0	110111101	0000000	1	2	5
0	0	0	110110011	0000000	1	2	5

0 1 0 0	100110010 000000
0 0 0 0	110110010 000000
0 0 0 0	100100101 000000
1 1 0 0	111111101 000000
0 0 0 0	100100101 000000
0 0 0 0	110110101 000000
0 0 0 0	111101011 000000
0 0 0 0	110110101 100110100
0 1 0 1	110110101 000000
0 0 0 0	100110101 000000
0 0 0 1	110111011 000000
0 1 0 1	110100101 000000
0 0 0 0	110111011 000000
0 0 0 0	110110111 000000
0 0 0 0	110110011 000000
0 0 0 1	100100101 000000
0 0 0 0	110100101 000000
0 0 0 0	000000 000000
1 0 1 0	110110101 000000
1 0 0 0	110100101 000000
1 1 0 1	110110101 000000
1 1 0 0	000000 000000
0 0 0 0	010110101 000000
0 0 1 1	110101011 000000
1 0 0 0	000000 000000

1 0 0	0 0	010110011	000000
1 1 0	0 0	110100101	000000
0 0	1 1 1	010110211	000000
0 0	1 0 0	111111010	000000
1 0	0 0 0 1	111111110	000000
1 0	1 0 0 1	110110110	000000
1 1 0	0 0 0	100110210	000000
0 1 0 1 0 0 0		110100100	000000
1 1 0 0 0		001011111	000000
0 0	1 0	100110011	000000
0 0	1 0 0	110110110	000000
0 0	0 0	000000	111111000
1 0 0	0 0	110110011	000000
0 0	0 0	100110101	000000
0 0	0 0	010110101	000000
1 1 0	0 0	110110101	000000
1 1 0	1 0 0 0	110110210	000000
0 0 0 0 0 0		110110101	000000
0 0	0 0	100110210	000000
1 1 0	0 0 0	000100100	000000
1 0 0	0 1	000000	000000
1 1 0	0 0 1 1	000000	000000
0 1 1 0 0		110110011	000000
0 0	0 0	110110011	000000
0 0	0 0	110110011	000000
0 0	1 0	110110210	000000

[illegible]

0	0	0	0
0	0	0	0
0	0	0	0
1	0	0	0
0	0	0	0
1	2	0	0
1	0	0	0
0	0	0	0
1	1	0	0
0	1	0	0
0	1	0	0
0	1	0	0
1	1	0	0
0	0	0	0
1	1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1	1	0	0
1	0	0	0
0	0	0	0

110111101 000000	1 4 2 5 4 208	21 4 14 1074 11 0 0 0 0 0 0 11 1 10101	15101 1 1 1 10101
110111101 000000	1 4 2 5 4 2	2144 4004 11 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15504 400 4 1 2 1074 11 0 0 0 0 0 0 0 0 0 0 0 0
100100101 000000	1 2 2 5 4 274	30 5 2 2 5000 000 000 000 000 000 000 000 000 000	15924 500 24 1 2 250 000 000 000 000 000 000 000 000 000
000000 000000	1 0 2 5 1 10	21 114 0002 11 0 0 0 0 0 0 0 0 0 0 0 0 0	40124 0 0 0 11 500 000 000 000 000 000 000 000 000
100110101 000000	1 4 2 5 1 22	42 0105 0100 010 010 010 010 010 010 010 010 010 010	15427 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12
110110101 000000	1 4 2 5 1 2	0 1 1 1 21 0 0 0 0 0 0 0 0 0 0 0 0 0	15627 13 13 13 13 13 13 13 13 13 13 13 13 13 13 13
110110101 000000	1 4 2 5 1 12	4 2 2 2 5012 502 1 2 0 0 0 0 0 0 0 0 0 0	15420 0 0 0 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2
100110101 000000	2 2 2 5 4 2	6 0 0 0 0104 102 12 0 0 0 0 0 0 0 0 0 0 0	15242 10 11 10 10 10 10 10 10 10 10 10 10 10 10 10
000100101 000000	1 0 2 5 1 100	40 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	15427 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
110110221 000000	1 0 2 5 1 414	46 5 25 4700 004 04 0 0 0 0 0 0 0 0 0 0 0	15627 22 22 10 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2
110110221 000000	1 2 2 5 1 02	2 4 02 3081 104 04 04 04 04 04 04 04 04 04 04 04	45014 2 2 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
110110221 000000	1 2 2 5 1	0 4 04 104 14 0 0 0 0 0 0 0 0 0 0 0 0 0	15027 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
110110101 000000	1 2 2 5 1 1 26	46 4 4 202 04 0 0 0 0 0 0 0 0 0 0 0 0 0	45027 1 1 6 1 1500 0 0 0 0 0 0 0 0 0 0 0 0 0
110110101 000000	1 4 2 5 1	4 25 5025 504	15027 0 10 1027 0 25 501 5025 504
000000 000000	1 2 2 5 1 421	21 1122 0000 104 12 0 0 0 0 0 0 0 0 0 0 0 0	03402 10 5 0 1 1040 0 21 501 000 104 12 0 0 0 0 0 0 0
101111101 000000	1 2 2 5 1 1 108	40 1 0 4 024 370 04 0 0 0 0 0 0 0 0 0 0 0	15046 04 04 11 00 1 040 04 04 04 04 04 04 04 04 04 04
000100101 000000	1 2 2 5 4 02	01 1111 2002 1002 04 04 04 04 04 04 04 04 04 04 04	15127 22 10 04 04 04 04 04 04 04 04 04 04 04 04 04 04
100100101 000000	1 2 2 5 4 04	17 014 04 04 04 04 04 04 04 04 04 04 04 04 04	15272 11 4 4 1100 0 4 04 04 04 04 04 04 04 04 04
000000 000000	1 2 2 5 4 04	17 04 04 04 04 04 04 04 04 04 04 04 04 04 04	15464 1 1 4 1100 0 4 04 04 04 04 04 04 04 04 04
10110101 01011010	1 2 2 5 4 04	14 1 1 024 275 04 0 0 0 0 0 0 0 0 0 0 0	15012 24 7 04 24 04 04 04 04 04 04 04 04 04 04
110110101 000000	1 2 2 5 4 04	14 1 1 024 275 04 04 04 04 04 04 04 04 04 04	15012 24 2 11 1100 0 27 04 04 04 04 04 04 04 04

COHORT "B"

Reader 6

"Normals"

pp. 316 - 336

"Less-than-normals"

pp. 337 - 348

[illegible]

50105 11 6 08 6876 A 0	1205 23 4 11	76 1 6 1 5 1
50173 25 11 20 6888 A 0	4536 47 8 1	135 1 5 1 0 1
50147 0 0 12 9130 A 0	2609 75 6 6	140 1 6 1 7 1
11072 19 7 16 7059 A 0	3307 6411 29	410 4 6 1 7 3
11076 13 6 19 6441 A 0	5803 6411 9	52 1 6 1 2 1
10662 27 7 13 9438 A 0	1909 6411 13	22 1 6 1 7 1
10796 25 6 14 9459 A 0	2610 6411 25	210 1 6 1 2 1
10792 2 6 14 9459 A 0	4609 6411 11	63 1 6 1 3 2
10785 2 13 19 6779 A 0	4609 6411 13	113 1 6 1 6 2
10759 21 5 13 6133 A 0	4507 6411 11	50 1 6 1 2 1
10732 4 19 20 7130 A 0	3911 6411 20	220 1 6 1 6 1
10691 21 7 4 9638 A 0	2910 6411 17	39 1 6 1 2 2
10590 19 13 14 6224 A 0	4603 6411 17	36 1 6 1 5 1
10525 14 1 7 9319 A 0	4510 6411 17	35 1 6 1 4 1
10496 30 1 14 6180 A 0	4508 6411 20	109 1 6 1 7 2
10097 30 8 17 3210 A 0	3609 6411 25	193 1 6 1 2 2
232 22 1 11 9431 A 0	2608 6411 14	1208 1 5 1 2 1
95 6 1 16 6302 A 0	4304 47 2 3	61 4 6 1 4 1
83 12 9 27 9030 A 0	2005 4410 41	123 4 6 1 2 3
40 17 2 06 6177 A 0	1610 4412 29	409 4 6 1 2 2
12 25 4 6 6336 A 0	5210 55 2 2	1 4 6 1 2 1
26 10 11 9 9444 A 0	4504 46 7 1	5 4 6 1 0 1
25 1 6 15 9813 A 0	4305 46 2 3	45 4 6 1 4 2
12 9 9 17 7243 A 0	4209 49 7 6	21 4 6 1 7 1
12 4 2 12 8026 A 0	2907 6310 21	563 4 6 1 7 1

[illegible]

50221	0	0	00	6531	A	0	1007	21	6	7	1103	1	6	1	0	2
50168	7	1	00	6905	A	0	4409	61	1	16	97	1	6	1	7	2
50455	26	9	10	5769	A	0	4505	48	7	1	12	1	6	1	7	1
50529	11	1	11	6771	A	0	2710	4610	9		13	1	6	1	0	2
50656	22	3	20	6670	A	0	4511	23	3	1	9	1	6	1	2	1
50734	0	0	07	6837	A	0	2008	47	3	1	9	1	6	1	2	1
50765	24	11	17	9001	A	0	3311	47	4	9	705	1	6	1	0	1
90001	24	9	7	7105	A	0	2909	6611	25	112	9	6	1	6	2	
90005	19	11	19	6749	A	0	4608	6711	30	90	9	6	1	7	3	
90007	0	0	16	6719	A	0	3907	6611	19	167	1	6	1	0	1	
90046	0	0	19	6780	A	0	3511	6411	19	278	1	6	1	4	1	
90061	0	0	12	7079	A	0	3405	6611	24	73	1	6	1	7	1	
40390	0	0	16	6439	A	0	3509	6611	27	1317	1	6	1	3	1	
90119	0	0	19	6018	A	0	4109	6611	24	93	9	6	1	0	2	
90125	24	9	14	6544	A	0	3806	6611	19	41	9	6	1	0	2	
90161	0	0	14	6466	A	0	3309	6611	27	191	1	6	1	7	1	
90231	0	0	17	7084	A	0	4204	6611	23	234	1	6	1	7	2	
90250	7	10	14	7147	A	0	4601	5611	12	67	1	6	1	7	1	
90300	30	4	17	6410	A	0	4105	54	1	7	243	9	6	1	6	1
90317	14	0	5	6075	A	0	2904	47	9	17	49	9	6	1	7	1
90319	0	0	15	6007	A	0	3609	5211	2	19	1	6	1	7	1	
90363	21	9	13	6070	A	0	3011	49	1	7	30	9	6	1	4	1
90370	12	7	7	7018	A	0	2612	4810	11	29	9	6	1	5	1	
90379	12	2	13	6061	A	0	2604	41	1	11	92	9	6	1	3	1
90520	0	0	13	6571	A	0	1005	2612	1		5	1	6	1	2	1

[illegible]

[illegible]

130958 24 13 13 1827 A 0	3734 6611 24	228 A 6 1 2 2
130959 19 12 14 2038 A 0	4027 6611 21	34 A 6 1 2 2
130174 19 4 16 6594 A 0	4634 6611 20	44 A 6 1 2 1
130932 7 5 15 4639 A 1	3221 6611 19	54 A 6 1 2 3
131313 27 5 3 5059 A 0	2334 6611 27	113 A 6 1 2 2
131347 3 7 14 9245 A 0	4505 6611 16	133 A 6 1 2 2
131344 4 2 11 5294 A 0	4697 6611 29	206 A 6 1 2 2
131356 6 7 14 7497 A 0	4106 6611 25	141 A 6 1 2 2
131392 13 1 16 6346 A 1	3529 6611 21	214 A 6 1 6 2
131336 7 3 16 7213 A 0	4625 6611 20	42 A 6 1 6 2
131139 23 5 18 6827 A 0	4936 6611 17	49 A 6 1 7 2
131133 25 7 9 4131 A 0	4103 6611 25	54 A 6 1 1 1 2
131154 5 4 3 6504 A 1	4624 6611 23	41 A 6 1 1 2 1
131158 11 11 13 5291 A 0	4709 6611 19	123 A 6 1 1 1 1
131121 7 9 15 3547 A 0	3735 6611 26	64 A 6 1 1 0 2
131141 5 4 4 7027 A 1	3906 6611 17	71 A 6 1 1 0 2
131240 41 9 16 4094 A 0	4591 6611 17	76 A 6 1 1 0 2
131262 2 1 17 4467 A 0	4804 6611 14	10 A 6 1 1 0 2 1
131537 4 3 17 3271 A 0	4112 6611 13	219 A 6 1 1 0 1
131537 15 8 14 3768 A 1	3286 6611 17	252 A 6 1 1 0 2
131471 24 7 15 6614 A 0	3634 6611 20	316 A 6 1 1 0 1
131437 11 7 13 3337 A 1	3512 6611 20	347 A 6 1 1 0 2
131433 24 4 13 4853 A 0	4504 6611 21	134 A 6 1 1 0 2
131467 4 7 9 7035 A 0	4172 6611 25	111 A 6 1 1 0 1
131539 24 9 13 3434 A 0	4727 6611 11 1	53 A 6 1 1 0 2

	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000
	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000
I	0	0	0	0	000000	000000

151564	1	13	14	6257	A	0	3698	6611	30	651	A	6	1	7	2	
151566	6	3	14	7014	A	0	3510	6611	31	66	A	6	1	3	2	
151569	15	4	3	9463	A	0	4506	6611	15	42	A	6	1	7	3	
151641	21	8	17	9838	A	0	4708	6611	19	52	A	6	1	8	3	
151645	3	10	12	9942	A	0	4901	6611	17	132	A	6	1	7	2	
151676	19	11	14	6759	A	0	3611	6611	33	30	A	6	1	5	2	
150028	13	9	12	7035	A	0	2906	47	4	17	493	A	6	1	6	1
150095	29	4	14	6676	A	0	5009	55	5	5	18	A	6	1	8	1
150398	25	12	17	6356	A	0	4107	4513	4	154	A	6	1	4	2	
150340	11	1	1	6640	A	0	2810	53	3	21	292	A	6	1	5	2
150193	8	2	11	9941	A	0	2408	4412	20	1242	A	6	1	7	2	
150441	18	12	19	6711	A	0	5101	51	4		A	6	1	6	1	
150551	19	8	13	6934	A	0	2904	44	7	19	993	A	6	1	7	1
150453	13	5	4	7292	A	0	2307	44	9	21	550	A	6	1	7	3
150401	17	9	29	7036	A	0	4601	4712	1		75	A	6	1	7	1
150333	6	10	29	7031	A	0	4904	59	8	1	45	A	6	1	5	2
150369	18	6	14	6483	A	0	4105	42	4	1	3	A	6	1	8	2
151166	29	3	11	9447	A	0	5507	55	9		A	6	1	5	1	
151262	24	12	29	9345	A	0	5511	6412	9		47	A	6	1	8	2
151425	33	9	11	6974	A	0	4207	45	4	2	25	A	6	1	6	2
151827	27	6	14	7936	A	0	3609	46	5	6	117	A	6	1	7	2
151977	16	9	13	6541	A	0	3610	45	8	3	436	A	6	1	6	1
152009	19	4	17	7130	A	0	3703	43	4	6	213	A	6	1	3	2
152323	13	9	15	6266	A	0	4210	46	2	3	31	A	6	1	7	2
152357	25	4	18	9933	A	0	4213	46	8	2	61	A	6	1	7	1

[illegible]

154130 24	3 15	6030 A 0	4304 51 6 2	13 A 6 1 3 1
154296 24	4 12	6404 A 3	3509 31 6 2	13 A 6 1 3 1
154136 12	4 14	7014 A 0	4809 49 12	9 A 6 1 2 3
154191 27	7 14	8716 A 0	3702 47 6 10	25 A 6 1 2 3
154425 10	2 16	9601 A 0	4905 61 5 12	31 A 6 1 2 3
154417 17	12 14	6005 A 0	4938 49 3	A 6 1 2 3
154564 9	3 6	5061 A 0	4609 59 3 11	15 A 6 1 4 1
154578 26	4 06	6006 A 0	3910 41 9 1	4 A 6 1 4 1
154757 23	3 19	6406 A 0	4608 49 4 2	23 A 6 1 4 1
154741 24	4 8	4162 A 3	2838 19 4 2	23 A 6 1 0 1
154741 6 11	6 09	6009 A 0	4110 47 7 1	14 A 6 1 0 1
155000 27	11 07	7042 A 0	2509 44 7 19	23 A 6 1 2 3
155109 27	12 16	7136 A 0	4706 47 7	A 6 1 2 3
155264 17	9 16	9194 A 0	4706 58 7 11	25 A 6 1 2 3
155503 13	4 30	6934 A 0	4610 48 7 1	13 A 6 1 0 1
155545 24	4 12	7016 A 0	4310 46 9 2	31 A 6 1 4 1
155714 15	12 11	7106 A 0	5210 54 2 1	7 A 6 1 4 1
155796 16	4 10	9736 A 0	4901 49 6	1 A 6 1 4 1
155457 21	10 16	6452 A 0	4802 56 5 8	13 A 6 1 4 1
155945 1	4 20	6429 A 0	4906 6110 14	33 A 6 1 2 3
156146 5	4 9	9591 A 0	2806 41 5 6	15 A 6 1 4 1
156199 3	1 11	8944 A 0	4705 59 2 4	17 A 6 1 4 1
156229 15	3 19	9147 A 0	3506 40 1 4	23 A 6 1 4 1
156279 19	12 15	9459 A 0	4701 51 7 4	13 A 6 1 2 3
156512 4	5 13	8356 A 0	4737 44 4	13 A 6 1 4 1

[illegible]

156985 24 13 17	7500 A 0	4411 4511 1	2 A 6 1 4 2
156401 11 3 15	4310 A 0	4707 47 0	A 6 1 7 1
155748 4 7 0	4074 A 0	4010 60 4 24	150 A 6 1 0 3
156043 34 11 15	4457 A 0	4605 40 4	A 6 1 7 2
156333 22 4 30	4474 A 0	2204 45 7 03	60 A 6 1 2 2
157016 13 7 12	4560 A 0	4126 47 7 6	40 A 6 1 4 2
157003 27 3 10	4117 A 0	4705 47 3	A 6 1 7 1
157044 20 9 13	4771 A 0	4412 45 5	1 A 6 1 6 2
157431 12 11 7	4040 A 0	3009 43 4 3	21 A 6 1 2 2
157556 27 4 15	4773 A 0	4510 44 1	1 A 6 1 5 3
157524 16 4 17	4001 A 0	2011 41 3 12	505 A 6 1 2 2
157558 3 7 0	4774 A 0	4700 40 11	1 A 6 1 5 1
157703 23 4 10	4773 A 0	6005 51 7 2	4 A 6 1 2 1
157757 13 2 10	4477 A 0	5213 52 3 5	10 A 6 1 4 3
157803 4 7 15	4037 A 0	4307 40 6 05	21 A 6 1 7 1
158204 5 4 0	4110 A 0	4505 44 11 24	261 A 6 1 4 1
158283 17 1 17	4174 A 0	5037 41 6	1 A 6 1 6 1
158317 1 13 7	4184 A 0	4501 41 3 3	7 A 6 1 6 1
158353 11 1 4	4000 A 0	4501 41 10	1 A 6 1 6 2
144303 17 5 4	4007 A 0	7704 47 3 3	404 A 6 1 0 2
158401 24 7 00	4007 A 0	4707 46 5 3	11 A 6 1 7 1
158337 7 12 3	4002 A 0	1404 43 4 20	1350 A 6 1 2 1
158433 13 5 00	4014 A 0	5007 43 5 0	3 A 6 1 5 3
158444 25 7 10	4013 A 0	4205 44 11	4 A 6 1 4 2
158741 43 0 10	4007 A 0	4000 40 10	A 6 1 2 1

[illegible]

159497	31	5	07	5780	A	0	4504	49	B	A	6	1		
158457	12	8	15	9417	A	0	4905	57	5	9	7	A	6	1
159432	23	6	13	8933	A	0	5607	58	5	1	3	A	6	1
159559	22	2	19	6910	A	0	4804	62	4	14	29	A	6	1
153253	6	5	0	9480	A	0	4208	64	6	21	46	A	6	1
159263	27	7	26	9590	A	0	2511	61	8	33	611	A	6	1
159331	4	4	14	6614	A	0	3305	45	6	13	213	A	6	1
159332	24	9	38	6757	A	0	4209	5910	20	37	17	A	6	1
159369	21	1	8	6795	A	0	4407	51	9	7	72	A	6	1
159398	9	2	95	9230	A	0	2607	63	3	31	47	A	6	1
159422	24	13	04	9427	A	0	2203	63	1	37	103	A	6	1
159447	27	3	18	6376	A	0	4296	46	6	4	9	A	6	1
159469	20	9	95	9794	A	0	1605	4010	25	223	A	6	1	
203373	20	5	23	9478	A	0	4006	6611	21	44	A	6	1	
200119	1	12	18	6204	A	0	4601	6611	20	45	A	6	1	
200166	13	11	29	9112	A	0	3911	6611	26	128	A	6	1	
200190	26	11	19	4490	A	0	3609	6611	24	59	A	6	1	
203257	1	10	17	9410	A	0	4509	6611	21	18	A	6	1	
200255	19	5	9	9243	A	0	3410	6611	29	26	A	6	1	
200301	28	13	6	5912	A	0	3705	6611	29	71	A	6	1	
250316	17	8	14	8429	A	0	4936	5712	8	17	A	6	1	
250104	7	1	1	6647	A	0	2201	24	6	145	A	6	1	
250141	7	12	12	6048	A	0	4107	4312	9	20	A	6	1	
250255	26	4	19	7034	A	0	4109	46	7	11	A	6	1	
250491	20	3	9	6219	A	0	4208	4412	2	3	A	6	1	

[illegible]

250599 27	4 1 4	5416 A	0	4701 5411	4	4 1 4	2
250612 11	0 19	6328 A	0	4509 4019	3	0 4 4	1 0 0
250616 21 11 12	0 0 0	4016 A	0	4603 4013 15	13	13 0 4	1 0 0
250617 0 17 19	0 19	7201 A	0	4711 51 3 4	4	20 4 5	1 2 1
250620 13	0 10	7007 A	0	4703 47 0 4	4	32 4 0	1 0 1
250621 15	0 20	4014 A	0	4700 4410 7	7	7 4 0	1 2 1
250623 21 10 21	0 21	6415 A	0	4709 53 3 5	5	11 4 0	1 2 1
250624 17	0 10	6000 A	0	4107 47 4 7	7	6 4 0	1 0 1
250625 24	7 35	6150 A	0	3501 43 4 25	25	15 4 0	1 0 2
250626 27	1 20	6710 A	0	4406 43 0	0	1 4 0	1 0 1
250628 11 11 10	0 10	6400 A	0	4002 51 2 1	1	15 4 0	1 7 1
250629 21	0 19	5400 A	0	4010 52 6 7	7	15 4 0	1 7 1
250630 13	0 4	6007 A	0	4712 54 5 4	4	0 4 0	1 7 1
250631 5 15	4 27	6476 A	0	4102 4211 5	5	12 4 0	1 7 2
250632 11	1 11	5001 A	0	2506 40 4 23	23	111 4 0	1 4 1
250633 12	1 12	7005 A	0	2307 46 1 25	25	184 4 0	1 2 2
250634 7	4 23	5344 A	0	4004 47 4	4	4 0 0	1 2 2
250635 13	0 15	5400 A	0	4208 46 0 4	4	39 4 0	1 4 3
250636 14	0 15	5400 A	0	4204 46 1 7	7	0 4 0	1 4 3
250637 27	4 23	6007 A	0	4011 4611 20	20	1174 1 6	1 1 1
250638 14	0 17	6007 A	0	4005 4611 13	13	1460 1 6	1 5 2
250639 17	0 14	61 4 A	0	4703 4311 11	11	107 1 6	1 7 1
250640 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250641 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250642 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250643 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250644 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250645 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250646 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250647 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250648 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250649 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250650 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250651 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250652 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250653 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250654 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250655 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250656 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250657 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250658 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250659 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250660 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250661 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250662 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250663 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250664 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250665 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250666 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250667 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250668 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250669 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250670 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250671 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250672 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250673 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250674 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250675 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250676 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250677 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250678 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250679 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250680 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250681 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250682 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250683 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250684 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250685 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250686 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250687 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250688 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250689 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250690 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250691 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250692 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250693 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250694 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250695 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250696 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250697 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250698 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250699 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1
250700 24	0 17	6400 A	0	4704 4411 11	11	40 1 6	1 0 1

[illegible]

[illegible]

1	0	0	0	0	000000	000000
2	0	0	0	0	000000	000000
3	0	0	0	0	000000	000000
4	0	0	0	0	000000	000000
5	0	0	0	0	000000	000000
6	0	0	0	0	000000	000000
7	0	0	0	0	000000	000000
8	0	0	0	0	000000	000000
9	0	0	0	0	000000	000000
10	0	0	0	0	000000	000000
11	0	0	0	0	000000	000000
12	0	0	0	0	000000	000000
13	0	0	0	0	000000	000000
14	0	0	0	0	000000	000000
15	0	0	0	0	000000	000000
16	0	0	0	0	000000	000000
17	0	0	0	0	000000	000000
18	0	0	0	0	000000	000000
19	0	0	0	0	000000	000000
20	0	0	0	0	000000	000000
21	0	0	0	0	000000	000000
22	0	0	0	0	000000	000000
23	0	0	0	0	000000	000000
24	0	0	0	0	000000	000000
25	0	0	0	0	000000	000000
26	0	0	0	0	000000	000000
27	0	0	0	0	000000	000000
28	0	0	0	0	000000	000000
29	0	0	0	0	000000	000000
30	0	0	0	0	000000	000000
31	0	0	0	0	000000	000000
32	0	0	0	0	000000	000000
33	0	0	0	0	000000	000000
34	0	0	0	0	000000	000000
35	0	0	0	0	000000	000000
36	0	0	0	0	000000	000000
37	0	0	0	0	000000	000000
38	0	0	0	0	000000	000000
39	0	0	0	0	000000	000000
40	0	0	0	0	000000	000000
41	0	0	0	0	000000	000000
42	0	0	0	0	000000	000000
43	0	0	0	0	000000	000000
44	0	0	0	0	000000	000000
45	0	0	0	0	000000	000000
46	0	0	0	0	000000	000000
47	0	0	0	0	000000	000000
48	0	0	0	0	000000	000000
49	0	0	0	0	000000	000000
50	0	0	0	0	000000	000000
51	0	0	0	0	000000	000000
52	0	0	0	0	000000	000000
53	0	0	0	0	000000	000000
54	0	0	0	0	000000	000000
55	0	0	0	0	000000	000000
56	0	0	0	0	000000	000000
57	0	0	0	0	000000	000000
58	0	0	0	0	000000	000000
59	0	0	0	0	000000	000000
60	0	0	0	0	000000	000000
61	0	0	0	0	000000	000000
62	0	0	0	0	000000	000000
63	0	0	0	0	000000	000000
64	0	0	0	0	000000	000000
65	0	0	0	0	000000	000000
66	0	0	0	0	000000	000000
67	0	0	0	0	000000	000000
68	0	0	0	0	000000	000000
69	0	0	0	0	000000	000000
70	0	0	0	0	000000	000000
71	0	0	0	0	0	

151146	A	4 17	7041	A	0	3005 5910	17	492	T	6 1 7 3	
151954	T	3 15	6893	A	0	4607 96 9		9	T	6 1 7 2	
152197	14	1 12	6093	A	0	4704 59	A	7	24	T	6 1 4 2
152419	29	3 08	7024	A	0	1811 64	8 35	268	T	6 1 4 1	
152444	10	2 13	8966	A	0	4910 44	6 14	211	T	6 1 4 1	
153367	26	6 14	6697	A	0	3709 42	7 8	1247	T	6 1 4 1	
153327	13	9 15	6674	A	0	4310 46	9 2	144	T	6 1 7 1	
153449	5 11	4 5835	A	0	4302 44	8 21	723	T	6 1 2 2		
153304	0 0	6 9196	A	0	3604 53	6 17	147	T	6 1 6 1		
153336	23	12 14	5969	A	0	3601 64	7 28	116	T	6 1 7 2	
154643	10	5 95	9310	A	0	1513 63	5 42	136	T	6 1 2 1	
154639	26	6 99	7145	A	0	4008 64	7 33	170	T	6 1 2 2	
155635	10	3 4	4969	A	0	2905 64	6 35	111	T	6 1 2 1	
155641	25	12 13	6747	A	0	4408 51	5 4	144	T	6 1 4 2	
155763	21	1 96	6695	A	0	1808 64	2 44	125	T	6 1 2 2	
157561	14	3 99	6505	A	0	1708 64	6 40	243	T	6 1 1 2	
157654	23	3 30	6433	A	0	8107 64	6 17	25	T	6 1 4 1	
157772	24	5 4	9432	A	0	4109 64	4 22	142	T	6 1 7 1	
157941	24	1 6	7947	A	0	5804 58	9	1	6	1 2 1	
400195	1	8 14	7249	A	0	2905 64	11 37	1270	T	6 1 4 1	
400567	28	6 17	7037	A	0	5104 64	11 15	57	T	6 1 1 1	
500174	5	4 14	9765	A	0	6511 64	11 1	2	1	6 1 2 1	
500216	7	3 17	9627	A	0	6511 64	11 1	2	1	6 1 0 2	
600021	4	1 19	9414	A	0	4607 64	11 17	141	T	6 1 7 2	
600049	10	4 15	8747	A	0	5703 64	11 7	14	T	6 1 7 1	

[illegible]

[illegible]

354310 3 17 6493 D 69 203 4001 47 5 7 50 T 6 1 9 1
 203216 26 2 10 5212 D 74 202 2611 6011 26 93 A 6 1 6 2
 301323 3 5 4 6041 D 69 203 3609 66 6 24 300 T 6 1 7 1
 153305 22 7 04 9032 D 66 204 3703 72 5 A 6 1 9 2
 150027 13 8 5 6045 D 65 241 4011 49 5 7 206 A 6 1 7 2
 115 2 7 13 9225 D 65 293 4106 52 3 10 109 A 6 1 7 1
 350346 0 0 19 7181 D 67 297 3702 47 6 6 1 6 1 9 1
 152619 21 8 13 6934 D 72 307 4209 41 7 5 A 6 1 9 2
 400246 11 11 7 9602 D 72 330 2701 5611 19 1076 T 6 1 6 1
 40047 9 7 5 9344 D 61 331 2737 46 4 2 67 A 6 1 0 1
 151740 7 4 6 8041 D 62 331 2406 60 9 36 101 A 6 1 4 2
 151764 19 6 8 6442 D 70 331 2604 57 8 31 82 A 6 1 3 1
 156384 11 3 2 7124 D 74 331 4205 43 4 5 42 A 6 1 6 1
 157010 13 3 9 6216 D 66 331 3508 47 7 11 653 A 6 1 6 1
 159473 1 12 98 9749 D 75 331 4319 6312 23 52 A 6 1 3 1
 251766 21 1 99 0600 D 70 331 1804 6010 37 239 T 6 1 7 2
 354662 0 0 2 7047 D 70 331 2211 47 5 22 439 T 6 1 6 1
 354329 24 11 99 8039 D 50 331 4108 57 3 15 28 T 6 1 7 2
 153493 13 1 9 9137 D 74 332 4107 4613 5 51 A 6 1 3 2
 350174 9 9 10 9244 D 64 332 5902 58 9 1 T 6 1 7 3
 352731 26 11 33 9866 D 70 332 1706 6111 30 173 T 6 1 2 3
 159215 6 3 4 9230 D 69 334 4311 63 3 16 34 A 6 1 2 1
 53264 3 0 11 6252 D 45 353 2603 43 7 5 109 T 6 1 7 1
 350200 27 12 2 9574 D 67 355 5802 54 9 19 T 6 1 2 3
 251351 8 11 0 6447 D 60 414 2303 43 5 25 43 A 6 1 4 1

[illegible]

40 23 7 18 5507 D 67 470 4507 47 1 4
 40022 1 4 98 7656 D 67 423 1912 19 4 1
 496 6 1 7 2
 53395 23 10 13 56 10 0 61 423 4407 56 7 19
 100255 4 11 2 7170 D 75 423 2210 6611 42
 100983 13 4 4 7141 D 74 423 2637 6611 39
 101334 5 7 5 6133 D 68 423 2704 6611 36
 101500 21 11 9 6211 D 74 423 4737 6611 39
 153823 21 2 12 6415 D 67 423 2410 66 7 37
 151062 30 0 19 6552 D 69 423 4011 61 9 1
 152140 1 9 19 9647 D 72 423 5104 54 6 6
 152114 6 10 5 5214 D 73 423 4904 6011 14
 152633 1 1 16 7042 D 67 423 4911 61 9 1
 154420 15 7 33 9142 D 66 423 4710 49 7 1
 155452 23 9 10 9191 D 75 423 4110 43 4 2
 155454 9 10 10 9870 D 68 423 4706 47 3
 155429 11 4 05 8734 D 57 423 511 57 6 47
 156413 27 11 04 8704 D 57 423 2506 38 1 14
 156 388 7 4 16 6012 D 60 423 4131 47 4 4
 157156 19 7 2 7554 D 76 423 2937 43 5 13
 157164 8 10 4 6542 D 70 423 1935 411 24
 157663 26 4 13 6727 D 67 423 5937 56 2 13
 158115 15 13 0 6774 5 61 423 4734 4113 13
 159239 5 7 16 9417 D 68 423 2635 43 7 41
 159238 6 1 0 7550 D 72 423 2504 38 7 37
 159249 7 10 05 7507 D 67 423 4712 41 1 1

	C	O	C	C	CCCCC	CCCCC
I	C	O	C	C	CCCCC	CCCCC
I	O	O	O	C	CCCCC	CCCCC
	O	O	O	C	CCCCC	CCCCC
	O	O	O	O	CCCCC	CCCCC
	O	C	C	C	CCCCC	CCCCC
	O	O	O	O	CCCCC	CCCCC
	O	O	O	O	CCCCC	CCCCC
I	O	O	O	C	CCCCC	CCCCC
	O	O	O	C	CCCCC	CCCCC
	O	O	C	O	CCCCC	CCCCC
I	O	O	C	O	CCCCC	CCCCC
	C	C	O	C	CCCCC	CCCCC
	O	O	O	O	CCCCC	CCCCC
	O	C	C	C	CCCCC	CCCCC
I	O	O	O	O	CCCCC	CCCCC
	O	C	C	C	CCCCC	CCCCC
	O	O	C	O	CCCCC	CCCCC
I	O	O	C	O	CCCCC	CCCCC
	C	C	C	C	CCCCC-C	CCCCC-C
I	O	C	O	C	CCCCC	CCCCC
	O	O	C	C	CCCCC	CCCCC
I	C	O	O	C	CCCCC	CCCCC
I	O	C	C	C	CCCCC	CCCCC

150464	22	0 06	7111	0 65	420	1407	00	1 43	1437	A 6 1 2 3
150416	6 10	97	6665	0 56	420	2111	6411	16	93	A 6 1 8 3
200305	0 1	0	5913	0 76	420	2507	6611	15	765	A 6 1 7 4
250367	19	8	6957	0 57	420	4908	57	1 7	3	A 6 1 2 2
250144	30	1 18	6734	0 72	420	4204	49	5 6	172	A 6 1 7 1
250603	24	5 13	6638	0 61	420	3611	34	4 3	64	A 6 1 7 3
251147	2	5 14	6664	0 71	420	4611	47	0	A	6 1 3 1
251417	22	1 2	6425	0 66	420	2205	66	8 41	222	A 6 1 4 2
251574	25	5 15	6932	0 61	420	4410	61	4 16	123	A 6 1 7 1
251642	23	9 92	6439	0 57	420	1311	46	8 22	105	A 6 1 2 3
303425	22	4 12	9031	0 68	420	5501	6611	11	23	A 6 1 7 1
301343	5	1 3	9121	0 67	420	4009	6611	15	151	A 6 1 2 4
350330	14	2 18	6057	0 71	420	3702	66	5 13	156	A 6 1 8 1
451571	22	4 7	6653	0 57	420	2511	57	2 21	605	A 6 1 6 3
452218	24	3 39	6937	0 57	420	1605	5712	41	164	A 6 1 6 2
564121	26	6 37	6664	0 66	420	2003	62	6 15	115	A 6 1 7 1
564221	41	1 3	6134	0 55	420	3425	65	1 13	705	A 6 1 7 3
564224	12	7 7	7055	0 74	420	4410	49	4 2	133	A 6 1 7 2
430313	7	5 13	3155	0 75	420	2608	6611	18	403	A 6 1 5 2
650362	17	1 17	6932	0 63	420	5103	63	7 12	333	A 6 1 7 2
150304	0	2 34	6613	0 53	420	1711	53	2 12	1254	A 6 1 6 2
251659	13	11	8	5937	0 65	420	4508	50	2	A 6 1 9

[illegible]

0	0	0	0	00000	00000
0	0	0	0	00000	00000
1	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
1	0	0	0	00000	00000
1	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
1	0	0	0	00000	00000
1	0	0	0	00000	00000
0	0	0	0	00000-0	00000-0
0	0	0	0	00000	00000
0	0	0	0	00000	00000
1	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000
1	0	0	0	00000	00000
0	0	0	0	00000	00000
0	0	0	0	00000	00000

251841	24	5 13	5479 1 49	4026 89 8	1 A 6 1 3 1	000000	000000	0 0 0 0
853827	3	4 17	8019 1 70	4704 57 0 10	87 1 6 1 0 2	000000	000000	0 0 0 0

[illegible]

[illegible]

1 0 0	0	0	0
0 0	0	0	
0 0	0	0	
1 0	0	0	
1 0	0	0	0
0 0	0	0	7
1 0 0	0	0	7
0 0	0	0	
0 0	0	0	
1 1 0	0	0	
0 0	0	0	1 3
1 0 0	0	0	
0 0	0	1	7
1 0	0	0	
1 1 0	0	0	
1 1 0	0	0	7
1 1 0	0	0	
1 1 0	0	0	
0 0	0	0	7
1 0 0	0	0	7
1 0	0	0	
1 0	0	0	
0 0	0	0	0
1 0 0	0	0	0
1 1 0	0	0	

0 0	0 0	0 1	000000	000000	1 0 0 0 0 0	0
1 1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
0 0	0 0	1 1 1	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 0 0	0 0	0	000000	11111110	1 0 0 0 0 0	0 1
0 0	0 0	0 1 1	000000	000000	1 0 0 0 0 0	0 1
0 0	0 0	0 0 1	000000	000000	1 0 0 0 0 0	0 1
1 0 0	0 0	0 0	000000	000000	1 0 0 0 0 0	0 1
1 1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
0 0	0 0	0 0 1	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
0 0	0 0	0	11010101	000000	1 0 0 0 0 0	0 1
1 1 0	0 0	0	10010001	000000	1 0 0 0 0 0	0 1
1 1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 0 0	0 0	0	000000	11000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0 0 0	000000	000000	1 0 0 0 0 0	0 1
1 0 0	0 0	0	10010011	000000	1 0 0 0 0 0	0 1
0 0	0 0	0 0 0	000000	000000	1 0 0 0 0 0	0 1
1 0	0 0	0	000000	000000	1 0 0 0 0 0	0 1
0 0	0 0	0 1 1	000000	000000	1 0 0 0 0 0	0 1

151026 21	9 18	0127	A	0	3504	A	12
151170 14	7 1	5271	A	0	1704	A	7
151615 4	8 2	4756	A	0	2431	A	4
152047 15	1 14	5277	A	0	4709	A	7
152225 5	2 12	5256	A	0	4007	A	11
152748 3	1 22	4278	A	0	4204	A	0
154137 26	13 13	6413	A	0	4705	A	1
154522 15	4 13	7174	A	0	4704	A	1
155022 20	3 17	4156	A	0	4403	A	5
155554 16	8 1	4758	A	0	2010	A	0
155707 10	2 0	6019	A	0	4601	A	3
155735 24	0 17	4545	A	0	5207	A	8
156274 23	1 19	4504	A	0	4106	A	1
156443 17	10 13	4436	A	0	4110	A	7
157222 24	2 4	4201	A	0	2007	A	13
157611 26	7 12	5411	A	0	2104	A	0
157643 27	4 17	7100	A	0	3703	A	0
157761 25	4 15	9715	A	0	4109	A	11
157763 12	5 14	6700	A	0	4703	A	5
157874 11	3 20	4434	A	0	5107	A	2
158267 23	4 15	4056	A	0	4411	A	5
158541 6	2 02	71 1	A	0	4127	A	0
158641 21	2 27	6004	A	0	4405	A	0
158642 21	2 27	6004	A	0	4405	A	0
158642 21	2 27	6004	A	0	4405	A	0

1 1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	00
0 0 0 0	01011111	000000	1 2 2 2 1 5 2 1	01
0 1 1 0 0 1	000100010	000000	2 2 2 2 1 5 2 1	02
0 0 0 1 0 0	11011111	000000	1 2 2 2 1 5 2 1	03
1 0 1 0 0 0	000000	000000	1 2 2 2 1 5 2 1	04
0 0 0 0	100100101	000000	2 2 2 2 1 5 2 1	05
0 1 0 1 0 0 0 0	000000	000000	1 2 2 2 1 5 2 1	06
1 0 0 0 0	010010101	000000	1 2 2 2 1 5 2 1	07
1 1 0 0 0	000000	000000	1 2 2 2 1 5 2 1	08
0 0 0 0	000000	00011111	1 2 2 2 1 5 2 1	09
0 0 0 0 0	000000	000000	1 2 2 2 1 5 2 1	10
0 0 0 0 0	000000	000000	2 2 2 2 1 5 2 1	11
0 0 0 0 0	000000	000000	1 2 2 2 1 5 2 1	12
1 0 0 0 0	000000	000000	1 2 2 2 1 5 2 1	13
1 1 0 0 0	000000	000000	1 2 2 2 1 5 2 1	14
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	15
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	16
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	17
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	18
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	19
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	20
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	21
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	22
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	23
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	24
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	25
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	26
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	27
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	28
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	29
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	30
1 1 1 0 0	000000	000000	1 2 2 2 1 5 2 1	31

33660	20	10	30	2019	A	0
33597	9	9	10	2019	A	0
29304	70	10	00	2020	A	0
33727	12	9	17	2000	A	0
33502	5	9	18	2004	A	0
33003	17	1	11	2525	A	0
30055	17	11	10	2050	A	0
30055	17	11	10	2050	A	0
33242	15	2	19	2019	A	0
30057	23	10	14	2179	A	0
20103	20	11	15	2004	A	0
30102	2	9	0	2007	A	0
30130	6	11	17	2000	A	0
30168	12	9	11	2017	A	0
10192	14	9	4	2004	A	0
10150	26	11	17	2019	A	0
30171	26	9	8	2007	A	0
10180	10	6	17	2007	A	0
10105	14	7	23	2004	A	0
10210	12	5	12	2004	A	0
30215	17	11	9	2007	A	0
10210	7	6	11	2004	A	0
10071	29	9	8	2004	A	0
35114	3	2	00	2007	A	0
10131	1	9	12	2004	A	0
10170	15	9	12	2004	A	0

0 0	0	0	7
0 0	2	1	90
0 0	0	0	9
0 0	0	1	77
1 2 0	0	0	
1 0 1	0	0	
0 0	0		100
0 0	0	1	87
1 2 0	0	0	
0 1	0	0	
0 0	0	0	
2 0	0	0	
0 0	0	0	
1 0 0	0	1	9
1 1 0	0	0	
0 0	0	2	0
0 0	0	0	
1 0	0	0	
0 0	0	0	
0 1 7 1 0	0	1	0
1 1 0	0	0	
1 0 1 0 0	0	0	
1 0	0	0	
1 0 0	0	0	7
1 0 0	1	1	00

0 0	0 0	11111111	000000	2 2 2 2 1 000
1 1 0	0 0	000000	000000	1 2 2 2 1 221
1 1 0	0 0 7	000000	000000	2 2 2 2 1
1 0	2 0	110110121	000000	2 2 2 2 1 010
1 1 0	0 0 0	00010101	000000	2 2 2 2 1 000
0 0	0 7 0 0	000000	000000	1 0 0 0 0 00
1 0	0 0	000000	000000	2 2 2 2 1 001
1 1 0	0 1 0 0	000000	000000	2 2 2 2 1 000
1 1 0	2 0	110110110	000000	2 2 2 2 1 101
1 1 0	0 0	000000	000000	2 2 2 2 0
0 0	1 1 7 7	110111211	000000	2 2 2 2 1 020
0 0	0 0	000000	010010110	2 2 2 2 1 120
0 1	7 0 0 2	000000	110110120	2 2 2 2 1 000
1 0	0 0	000000	000000	2 2 2 2 1 000
1 0	0 0	000000	000000	2 2 2 2 1 2011
1 1 0	0 0 0 0	100110721	000000	2 2 2 2 1 2011
1 1 0	0 0	000000	010010110	2 2 2 2 1 01
1 0 100	0 1 0 0	110110011	000000	1 0 2 2 1 02
0 0	0 0	111111.11	000000	2 2 2 2 1 001
1 1 0	0 0 7	010010100	000000	1 2 2 2 1 000
1 0 0	0 0	00010101	000000	2 2 2 2 1 1001
1 1 0	0 0 0	100110011	000000	2 2 2 2 1 10
0 0	0 0	000000	110010100	2 2 2 2 1 0210
1 0	0 0	000000	000110110	1 0 2 2 1 000
0 0	0 0 0	000000	000000	1 2 2 2 1 200

300646	1	9	14	0040	0	74	420	2701	6511	25
351785	24	7	11	0470	0	65	420	3911	6511	24
352150	1	0	5	0064	0	61	420	2403	51	1
352250	0	0	0	0150	0	60	420	1804	70	2
353053	28	0	03	6291	0	69	420	606	61	0
354524	3	10	4	6640	0	66	420	1606	66	0
354641	3	9	06	0648	0	72	420	1001	64	4
355547	0	0	0	6525	0	60	420	1711	2911	3
356500	0	0	11	6563	0	56	420	2506	33	9
357204	21	9	12	0583	0	63	420	2901	63	4
450062	30	12	0	6472	0	61	420	2309	51	8
450279	18	5	03	6300	0	66	420	703	63	1
450554	24	7	5	6470	0	69	420	2501	50	3
600146	22	3	14	7204	0	71	420	4608	6411	19
500211	1	4	00	6347	0	69	420	1807	6012	71
152190	24	11	6	9335	0	65	420	4207	4310	
100769	22	0	0	5762	0	70	420	2704	6711	20
157646	0	0	07	6113	0	51	420	2408	51	4
900102	11	11	19	6530	0	69	420	4005	6611	26
40027	0	3	02	6574	0	65	420	905	4411	8
151525	6	10	07	1276	0	69	420	2506	6510	25
356651	2	7	06	6204	0	65	420	2001	6410	26
356720	0	0	04	7163	0	71	420	2303	21	5
352790	8	7	0	9308	0	75	420	2507	64	6
355323	29	0	02	7240	0	65	420	1205	54	8

00	00	00	11111111	000000	000000	000000
110	00	00	000000	000000	000000	000000
110	00	00	000000	000000	000000	000000
10	20	00	110110121	000000	000000	000000
110	00	00	000010101	000000	000000	000000
00	00	00	000000	000000	000000	000000
10	00	00	000000	000000	000000	000000
110	00	00	000000	000000	000000	000000
110	00	00	110110110	000000	000000	000000
110	00	00	000000	000000	000000	000000
00	11	11	11011011	000000	000000	000000
00	00	00	000000	010101110	000000	000000
01	10	00	000000	110110120	000000	000000
10	00	00	000000	000000	000000	000000
10	00	00	000000	000000	000000	000000
110	00	00	100110221	000000	000000	000000
110	00	00	000000	010101110	000000	000000
10100	00	00	110110011	000000	000000	000000
00	00	00	11111111	000000	000000	000000
110	00	00	100101010	000000	000000	000000
100	00	00	000101011	000000	000000	000000
110	00	00	10011011	000000	000000	000000
00	00	00	000000	010101100	000000	000000
10	00	00	000000	000101112	000000	000000
00	00	00	000000	000000	000000	000000

